Fishery Management Report No. 10-37

A Compilation of the 2009 Spiridon Lake Sockeye Salmon Enhancement Project Results: A Report to the Kodiak National Wildlife Refuge

by

Steven Thomsen

October 2010

Alaska Department of Fish and Game **Divisions of Sport Fish and Commercial Fisheries**

Symbols and Abbreviations

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	\$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	log_2, etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

FISHERY MANAGEMENT REPORT NO. 10-37

A COMPILATION OF THE 2009 SPIRIDON LAKE SOCKEYE SALMON ENHANCEMENT PROJECT RESULTS: A REPORT TO THE KODIAK NATIONAL WILDLIFE REFUGE

by
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The Kodiak Regional Aquaculture Association (KRAA) funds the general operations of the Spiridon Lake sockeye salmon stocking project and Pillar Creek Hatchery. The Division of Commercial Fisheries provides biological oversight and evaluation in the management of returning adult runs to the enhanced or rehabilitated systems associated with hatchery stocking projects.

The Fishery Management Reports series was established in 1989 by the Division of Sport Fish for the publication of an overview of management activities and goals in a specific geographic area, and became a joint divisional series in 2004 with the Division of Commercial Fisheries. Fishery Management Reports are intended for fishery and other technical professionals, as well as lay persons. Fishery Management Reports are available through the Alaska State Library and on the Internet: http://www.sf.adfg.state.ak.us/statewide/divreports/html/intersearch.cfm. This publication has undergone regional peer review.

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TABLE OF CONTENTS

Page

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABSTRACT

A sockeye salmon *Oncorhynchus nerka* enhancement stocking project was initiated at Spiridon Lake in 1990 to provide increased harvest opportunities for fishermen in the Kodiak Management Area. Because Spiridon Lake lies within the boundaries of the Kodiak National Wildlife Refuge, the Spiridon Lake Management Plan requires that the Alaska Department of Fish and Game collect water quality and zooplankton data, estimate the smolt outmigration, record juvenile salmon stocking numbers, and document the commercial salmon harvest to ensure the project remains compatible with the Kodiak National Wildlife Refuge mission.

In 2009, Spiridon Lake had a total nitrogen to total phosphorus ratio of 248:1, a total ammonia level of 4.6 µg/L at the 1m depth, and a chlorophyll-*a* concentration of 0.44 µg/L. The zooplankton community had a *Diaptomus* to *Cyclops* ratio of 0.04:1, a copepod biomass of 9.6 mg/m^3, a *Bosmina* to *Daphnia* ratio of 5.38:1, a cladoceran biomass of 6.21 mg/m^3, and a *Bosmina* size (average length) of 0.54 mm. In 2009, an estimated 327,923 sockeye salmon smolt emigrated from Spiridon Lake while a total of 1,475,160 sockeye salmon juveniles were released into the lake. A total of 81,725 adult sockeye salmon were harvested in the Spiridon Bay Special Harvest Area as reported on commercial fish harvest tickets. A total of 155,025 adult sockeye salmon were allocated as commercial harvest within the Kodiak Management Area from the Spiridon Lake enhancement project.

The 2009 Spiridon Lake enhancement project met all the KNWR monitoring criteria, except for the *Bosmina* to *Daphnia* ratio, which was greater than the maximum ratio specified in the Spiridon Lake Management Plan. With the improved zooplankton biomass in 2009, a stocking release of approximately 3.0 million fry is recommended for Spiridon Lake in 2010.

Key words: Spiridon Lake, Telrod Cove, Spiridon Bay Special Harvest Area, SBSHA, Kodiak Management Area, *Oncorhynchus nerka*, sockeye salmon, stocking, Kodiak National Wildlife Refuge, KNWR, U.S. Fish and Wildlife Service, USFWS, Kodiak Regional Aquaculture Association, KRAA, Special Use Permit, limnology, zooplankton.

INTRODUCTION

Spiridon Lake (57°40’ N lat, 153°39’ W long) is located in the Kodiak Unit of the Kodiak National Wildlife Refuge (KNWR) on the northwest side of Kodiak Island (Figure 1), approximately 74 km west of the City of Kodiak. The lake is 9.6 km long, 1.6 km at its widest point, has a surface area of 9.2 km^2, and a volume of 318 km^3 (Figures 1 and 2; Schrof and Honnold 2003). Spiridon Lake is at an elevation of 136 m, has a mean depth of 34.7 m, and a maximum depth of 82.0 m. The Spiridon Lake outlet stream (Telrod Creek) is approximately 2.0 km long and empties into Telrod Cove. Telrod Creek has three waterfalls that are impassable to fish. Two of the waterfalls are located approximately 0.8 km downstream of the lake outlet, and a third waterfall, located near the stream terminus, blocks salmon from migrating further upstream. Resident fish in Spiridon Lake include: rainbow trout *Onchorhynchus mykiss*, Dolly Varden char *Salvenlinus malma*, threespine stickleback *Gasterosteus aculeatus*, and freshwater sculpin *Cottus aleuticus* (Honnold 1997).

The impetus behind starting an enhancement project at Spiridon Lake is that the system does not support an anadromous fish run due to the falls mentioned previously. The stocking project was initiated to utilize the lake’s freshwater rearing environment without dramatically altering the nutrient balance or forage base (macrozooplankton) of the lake. Sockeye salmon fry are stocked into the lake at levels based on in-season limnological assessments of nutrients and zooplankton biomass (forage). Studying the stocking of a barren lake also provides researchers and managers with the opportunity to thoroughly assess the response of the macrozooplankton community to predation by juvenile salmon (Kyle 1996).

In December 1990, the Alaska Department of Fish and Game (ADF&G) in cooperation with Kodiak Regional Aquaculture Association (KRAA) submitted a proposal to the United States

Fish and Wildlife Service (USFWS) to begin a sockeye salmon *O. nerka* stocking project at Spiridon Lake. The KNWR permitted ADF&G to begin stocking Spiridon Lake to determine if a stocking project would be feasible and compatible with the guiding principles of the KNWR (Chatto 2000). The KNWR prepared an environmental assessment for the proposed project, which found no significant impact for the enhancement project (USFWS 1991). The following year, the KNWR issued a temporary five-year Special Use Permit (SUP) for the Spiridon Lake project to ADF&G. The SUP allowed ADF&G to proceed with the stocking project, so that additional baseline data could be collected to evaluate the stocking impacts to the lake's ecological community and adult returns to Telrod Cove. In 1997, the department consolidated and thoroughly evaluated all available fishery and limnological data from the Spiridon Lake stocking project into one document (Honnold 1997), which was used as a reference by the KNWR to write the Spiridon Lake Management Plan (SLMP; Chatto 2000). The SLMP was authorized by the KNWR in June 2000 along with a 5-year renewable SUP (updated in 2005) to continue stocking sockeye salmon, monitoring the lake ecosystem, and determining sockeye salmon production from Spiridon Lake.

Juvenile sockeye salmon have been stocked annually into Spiridon Lake since 1990 (Foster et al. 2009a). In 2009, the brood source utilized for stocking Spiridon Lake was from Saltery Lake. Historically, juvenile sockeye salmon stocked into Spiridon Lake have come from either Upper Station or Saltery Lakes. Juvenile salmon are stocked aerially, via fixed-wing aircraft. Since 1991, ADF&G has annually enumerated the smolt migrating out of Spiridon Lake and has collected samples from a portion of the smolt outmigration for age, weight, length (AWL) and condition. The returning adult sockeye salmon are harvested in the Spiridon Bay Special Harvest Area (SBSHA) as well as other westside harvest areas, since 1994 (Figure 1). ADF&G has annually monitored the fishery and sampled a portion of the sockeye salmon commercial catch for age, sex, and length data (ASL) in Telrod Cove.

Seasonal zooplankton production commonly varies from year to year and fluctuates considerably within a given season. The variation in production can be attributed to many factors; especially, environmental variation, predation, and inter-competition for habitat. Maintaining Spiridon Lake's biological integrity while maximizing sockeye salmon smolt production necessitates an understanding of these complex interactions.

Previous review of zooplankton interactions in Spiridon Lake consisted of a limited data set and could only conclude that juvenile sockeye salmon stocking was not likely related to the zooplankton composition (Honnold 1997). Regardless, assuming some influence based on conclusions from other lake studies, stocking levels in Spiridon Lake has been recommended based on zooplankton species composition and abundance.

MANAGEMENT PLAN MONITORING CRITERIA

Monitoring criteria were established from data collected at Spiridon Lake from 1987 to 1999 (Appendix A1, A2, and A3). The SLMP contains specific limnological and fishery measurement guidelines to ensure that juvenile sockeye salmon stocking levels do not substantially change Spiridon Lake. Specific attributes monitored include lake nutrient concentrations (nitrogen, phosphorus, total ammonia, and chlorophyll *a*); zooplankton composition, density, and biomass; smolt production; and adult harvest estimates (Chatto 2000).

The SLMP documents the various components of the stocking project, outlines how the project will be managed to remain compatible with the KNWR's mission, and serves as a reference document to guide any proposed changes to project operations (Chatto 2000). This report consolidates and summarizes the 2009 and historical data collected as part of the Spiridon Lake sockeye salmon enhancement project and compares these data to the SLMP guidelines.

Management Plan Objectives

The management plan contains six objectives:

1. Monitor water quality in Spiridon Lake to ensure compatibility with the SLMP criteria.
2. Monitor zooplankton in Spiridon Lake to ensure compatibility with the SLMP criteria.
3. Estimate the number of outmigrating sockeye salmon smolt and evaluate their growth and survival.
4. Stock juvenile sockeye salmon at densities based on historical and annual limnological data.
5. Document the commercial salmon harvest within the SBSHA to monitor the interception of natural salmon stocks.
6. Estimate pink, chum, and coho salmon escapements into Spiridon River by aerial survey.

METHODS

Limnological Monitoring

Comparative criteria specified in the SLMP were: total nitrogen (TN) to total phosphorus (TP) ratio, total ammonia (TA), chlorophyll *a* (Chl *a*), *Diaptomus* to *Cyclops* density ratio, copepod biomass, *Bosmina* to *Daphnia* density ratio, cladoceran biomass, and cladoceran (*Bosmina*) average size.

Lake Sampling Protocol

Samples were collected from Spiridon Lake five times from May to September at approximately four-week intervals. Two sampling stations were established in the deepest basins of the lake using a Global Positioning System (GPS; Figure 2). Samples were collected following standard ADF&G sampling procedures from Koenings et al. (1987), Thomsen (2008), and Foster et al. (2009b).

Water samples for chemistry and nutrient analysis were collected at the 1 m (epilimnion) and 50 m (hypolimnion) depths using a 4 L Van Dorn bottle and emptied into separate, pre-cleaned polyethylene carboys, which were kept cool and dark in the float of the plane until processed at the Near Island Laboratory (NIL) in Kodiak. Vertical zooplankton hauls were made at each station using a 0.2 m diameter conical net with 153 µm mesh. The net was pulled manually at a constant speed (~0.5 m/s) from approximately 50 m to the lake surface. The contents from each tow were emptied into a 125 ml poly bottle and preserved in 10% neutralized formalin.

General Water Chemistry and Nutrients

Unfiltered water was analyzed for TP, Total Kjeldahl Nitrogen (TKN), pH, and alkalinity. Sample water was filtered through a rinsed 4.25 cm diameter Whatman GF/F filter pad and stored frozen in phosphate free soap-washed polyethylene bottles. Filtered water was analyzed for total filterable phosphorus (TFP), filterable reactive phosphorus (FRP), nitrate+nitrite (N+N), and TA. A Spectronic Genesys 5 Spectrophotometer (SG5) was used for TP, TFP, FRP, N+N, and TA analyses.

The potassium persulfate-sulfuric acid digestion method described in Koenings et al. (1987) and Thomsen (2008) adapted from methods in Eisenreich et al. (1975) was used for TP analysis. Unfiltered frozen water samples were sent to the South Dakota State University laboratory for the TKN analysis using the EPA 351.3 (Nesslerization) method. The pH of water samples was measured with a Corning 430 meter, while alkalinity (mg/L as $CaCO_3$) was determined from 100 ml of unfiltered water titrated with 0.02 N H_2SO_4 to a pH of 4.5 and measured with a Mettler Toledo Seven Easy pH meter. Separate meters were used for the measurement of pH and alkalinity for added speed and accuracy.

Determination of TFP used the same methods as those for TP utilizing filtered water. The potassium persulfate-sulfuric acid method described in Koenings et al. (1987) and Thomsen (2008) was used for FRP analysis. Samples for N+N were analyzed using the cadmium reduction column method described in Koenings et al. (1987) and Thomsen (2008). The phenol-sodium hypochlorite method described in Koenings et al. (1987) and Thomsen (2008) was used for determining TA. Total nitrogen, the sum of TKN and N+N, were calculated for each sample in addition to the ratio of total nitrogen to total phosphorus.

Chlorophyll *a*

For Chl-*a* analysis, 1.0 L of water from each sample was filtered through a Whatman GF/F filter under 15 pounds per square inch of vacuum pressure. Approximately 5 ml of magnesium chloride ($MgCO_3$) was added to the final 50 ml of water to preserve the sample. Filters were stored frozen and in individual plexiglass slides until analyzed. Filters were then ground in 90% buffered acetone using a mortar and pestle, and the resulting slurry was refrigerated in separate 15 ml glass centrifuge tubes for 2 to 3 hours to ensure maximum pigment extraction. Pigment extracts were centrifuged, decanted, and diluted to 15 ml with 90% acetone. The extracts were analyzed with the SGS using methods described by Koenings et al. (1987) and Thomsen (2008). The Chl-*a* measurements were averaged from water samples collected at two sampling stations.

Zooplankton

For zooplankton analysis, cladocerans and copepods were identified according to taxonomic keys in Edmondson (1959). Zooplankton were individually measured in triplicate 1-ml subsamples taken with a Hansen-Stempel pipette and placed in a Sedgewick-Rafter counting chamber. Lengths from a minimum of 15 animals of each genus or species if possible were measured to the nearest 0.01 mm. A student's t-test was employed to determine the number of measurements needed to meet sample size requirements (Koenings 1987 and Thomsen 2008), and the mean was calculated. Density is the number of individuals per unit volume and reported in this publication as the number per meter cubed (No./m^3). Biomass was estimated using density and species-specific linear regression equations between length and dry weight derived by Koenings et al. (1987). Zooplankton data from the two stations were averaged for each survey date.

STOCKING

Stocking densities for Spiridon Lake were determined by estimating the lake's rearing capacity based on in season zooplankton biomass from May through July (Finkle and Byrne 2009). Saltery Lake sockeye salmon eggs were collected in early September of 2008 by Pillar Creek Hatchery (PCH) personnel using standard fish culture procedures (ADF&G 1994). Eggs were flown back to Kodiak, incubated and reared at PCH, and the juvenile salmon were then aerially released into Spiridon Lake via fixed-wing aircraft (Table 8).

SMOLT MONITORING

ADF&G personnel monitored, estimated, and sampled the sockeye salmon smolt emigration from Spiridon Lake (Appendix B1 and B2). Sockeye salmon smolt that emigrated from the lake were funneled into a counting tank utilizing two Canadian fan-traps, enumerated, and released into a pipeline bypass system that circumvented the barrier falls (Chatto 2000; Foster et al. 2009a) installed in the Spiridon Lake outlet creek (Telrod Creek). A 15-cm diameter black polyethylene pipeline provided smolt passage around the falls carrying water and smolt approximately 0.75 km, dropping about 90 m in elevation where the pipeline terminated and smolt exited into lower Telrod Creek. As in past years, timed counts were conducted to estimate the number of emigrating smolt (Foster et al. 2009a). Forty smolt were sampled five days a week for AWL data (Foster et al. 2009a). Once smolt emigration ceased, the bypass system was removed from the creek and stored on the stream banks.

HARVEST MONITORING

Harvest within the SBSHA was monitored by ADG&G personnel stationed at a camp on the outer eastern shoreline of Telrod Cove (Figure 1; Chatto 2000). Monitoring activities included assessing sockeye salmon run strength, recording fishing effort, estimating the commercial catch by species, and sampling a portion of the sockeye salmon catch for ASL data (Foster et al. 2009a; Schrof and Honnold 2003). The ADF&G fish ticket database was used to generate end-of-season catch summaries and to confirm on-site estimates.

ESCAPEMENT MONITORING

As established in the SLMP, aerial surveys of the Spiridon River drainage and Spiridon Bay were conducted in August with fixed-wing aircraft. These surveys were conducted to monitor chum, pink, and coho salmon escapements of surrounding systems and alleviate concern over interception of Spiridon River stocks harvested in SBSHA. Live and dead salmon were enumerated by species. Although no longer required in the SUP, the field crew conducted a foot survey of Telrod Creek during the commercial fishery to estimate sockeye salmon and pink salmon *O. gorbuscha* escapements.

RESULTS

LIMNOLOGICAL MONITORING

Total Nitrogen to Total Phosphorus Ratio

The mean epilimnion total nitrogen to total phosphorus ratio (TN:TP) in Spiridon Lake was 248:1 in 2009 (Tables 1 and 2; Appendix A3), which was within the desired range of 148:1 to 273:1, specified in the SLMP (Table 1). The 2009 epilimnion mean was slightly higher than the historical average of 227:1 from 1990 to 2008 (Table 2).

Total Ammonia

The 2009 total ammonia concentration in Spiridon Lake averaged 4.4 µg/L at Station 1 and 4.8 µg/L at Station 2 (Table 3). The 2009 seasonal mean concentration for total ammonia was 4.6 µg/L (Tables 1 and 3). The 2009 seasonal mean ammonia concentration was lower than the average concentration (5.9 µg/L) during the years (1990 to 2008) of stocking, but was within the range of 1.6 to 11.2 µg/L specified in the SLMP (Tables 1 and 3).

Chlorophyll *a*

Chl-*a* levels in Spiridon Lake averaged 0.44 µg/L at the 1 m depth in 2009 (0.54 µg/L at Station 1 and 0.34 µg/L at Station 2; Table 3). The average Chl-*a* concentration was within the specified range of 0.1 to 1.0 µg/L (Table 1). The seasonal average Chl-*a* concentration was near the historical 1990 to 2008 mean of 0.47 µg/L (Table 3).

Total Zooplankton

The 2009 seasonal mean zooplankton density in Spiridon Lake was 5,364 No./m^3 and the biomass was 15.80 mg/m^3 (Table 4; Figure 3). The 2009 total zooplankton density and biomass were close to the average values from 1990 to 2008 (5,747 No./m^3; 14.50 mg/m^3; Table 4). The 2009 cladoceran to copepod biomass ratio was 0.65:1 and the cladoceran to copepod density ratio was 0.39:1 (Table 4). The average (1990 to 2008) cladoceran to copepod biomass ratio was 0.62:1 and the cladoceran to copepod density ratio was 0.38:1 (Table 4).

Copepod Biomass

The average density of copepods in Spiridon Lake in 2009 was 3,865 No./m^3 and the average biomass was 9.59 mg/m^3, which was within the criteria range of 3.5 to 21.7 mg/m^3 identified in the SLMP (Tables 1, 4, and 5). The average copepod density from 1990 to 2008 was 4,170 No./m^3 and the average biomass was 8.93 mg/m^3 (Tables 4 and 5).

Diaptomus to Cyclops Density Ratio

The *Diaptomus* to *Cyclops* ratio was 0.04:1, falling within the criteria range (0.01:1 to 0.54:1) specified in the SLMP (Tables 1 and 5). The average ratio from 1990 to 2008 was 0.11:1 and the average ratio from 1988 to 1989 was 0.31:1.

Cladoceran Biomass

The 2009 seasonal average cladoceran density in Spiridon Lake was 1,499 No./m^3 with an average biomass of 6.21 mg/m^3, which was within the SLMP criteria range of 2.6 to 6.8 mg/m^3 (Tables 1, 4, and 6). The 2009 average biomass of 6.21 mg/m^3 was somewhat greater than the 1990 to 2008 average cladoceran biomass of 5.57 mg/m^3 and the 2009 density (1,499 No./m^3) was slightly below the 1990 to 2008 average of 1,577 No./m^3 (Tables 4 and 6).

Bosmina to Daphnia Density Ratio

The *Bosmina* to *Daphnia* ratio of 5.38:1 was well outside of the criteria range (0.22:1 to 1.73:1) specified in the SLMP (Tables 1 and 6). The average ratio from 1990 to 2008 was 0.98:1.

Cladoceran (Bosmina) Size

In 2009, the cladoceran *Bosmina* averaged 0.54 mm in length, which met the criteria (≥ 0.51 mm) specified in the SLMP (Tables 1 and 7). This compares to the average *Bosmina* size from 1990 to 2008 of 0.53 mm and the average pre-stocking (1988 to 1989) size of 0.58 mm.

STOCKING

Approximately 1,475,160 (average 0.46 g) sockeye salmon fry were stocked into Spiridon Lake on 8 July 2009 by fixed-winged aircraft. The average total sockeye salmon release into Spiridon Lake from 1991 to 2008 was 3,176,270 (Table 8).

SMOLT MONITORING

Approximately 327,923 live sockeye salmon smolt emigrated from Spiridon Lake from 12 May to 5 July in 2009 (Table 9). The average emigration from 1992 to 2008 was 815,559 sockeye salmon smolt. Smolt mortality in the trapping/bypass system was slightly higher than the mean from 1992 through 2008 (2%), at 2.6% in 2009 (Table 9).

The age composition of the total 2009 outmigration was predominately age-2. (60.6%) and the remaining smolt emigrating were age-1. (39.4%; Table 9). This compares to the average (1992 to 2008) age composition of Spiridon Lake sockeye salmon smolt which was 77.7% age-1., followed by 22.1% age-2., and 0.2% age-3. smolt.

In 2009, age-1. smolt captured in the trap averaged 101 mm in length and weighed 8.6 g and age-2. smolt captured in the trap averaged 137 mm in length and weighed 20.8 g (Table 10). Age-3. smolt were not captured in the trap in 2009. The average (1992 to 2008) length and weight of age-1. smolt captured in the trap was 108 mm and 10.8 g and the average length and weight of age-2. smolt was 149 mm and 29.4 g.

In 2009, the average condition of age-1. smolt captured in the trap was 0.82 K and age-2. smolt captured in the trap averaged 0.77K. This compares to the historical average (1992 to 2008) condition for both age-1. and age-2. of 0.81 K (Table 10).

HARVEST MONITORING

In 2009, the commercial harvest monitoring camp in Telrod Cove was operated from 20 June to 2 August. Commercial salmon harvests in the SBSHA occurred from 21 June through 17 August in 2009 (Table 11). Approximately 81,725 sockeye salmon, 0 coho salmon *O. kisutch*, 48,921 pink salmon, and 6,081 chum salmon *O. keta* were harvested in Telrod Cove (Dinnocenzo 2010; Tables 11 and 12). The 2009 SBSHA harvest was lower than the 1994 to 2008 average harvest for sockeye (110,404), coho (1,535), and pink (68,266) but greater for chum (6,079).

From 21 June to 2 August a total of 1,400 ASL samples were collected in the FBSHA. A total of 305 ASL samples were collected from sockeye salmon set net sites in statistical area 254-40 (Figure 1). Age-1.3 sockeye salmon comprised the majority (48.6%) of the SBSHA harvest in 2009, while the age-2.2 fish comprised 20.8%, the age-1.2 fish comprised 20.0%, and the age-2.3 fish comprised 8.3% of the harvest (Table 13). Historically (1994 to 2008), the age-1.2 component has averaged slightly more than half of the Telrod Cove harvest (54.5%), while the age-1.3 component has averaged 25.4%, the age-2.2 component has averaged 15.3%, and age-2.3 comprised 2.1%.

ESCAPEMENT MONITORING

Telrod Creek

Although no longer required as part of the SUP, a stream survey of Telrod Creek was conducted downstream of the terminal falls on 31 July 2009. A total of 25 sockeye salmon and no pink salmon were observed (Table 14).

Spiridon River

The indexed peak pink salmon escapement count into the Spiridon River (stream #254-401; not a part of Spiridon Lake Drainage; Figure 1) was estimated by aerial survey to be 13,400 fish on 9

August (Table 15). An indexed peak chum salmon escapement count of 25,000 fish was estimated by aerial survey (24 August). No coho salmon were observed in the surveys. One hundred sockeye salmon carcasses were observed on the 9 August survey.

DISCUSSION

Relationships surrounding "whole lake" interactions and salmon smolt production are complex. Spiridon Lake, as a barren system, provides a unique opportunity to explore some of these complex interactions. Barren lakes typically have a lower productivity than lakes with returning adult sockeye salmon due to a lack of marine derived nutrient input from returning adult sockeye salmon and the limits of allochthonous input (Kyle 1996; Sweetman 2001). As a stocked lake, the juvenile salmon density, size, and age at stocking into Spiridon Lake can be controlled. The trap system captures nearly all of the outmigrating smolt, giving a very reliable estimate of the subsequent smolt survival, size, weight, and condition at outmigration. Further, the corresponding adult returns and age structure are estimated annually. This report marks the first exploratory look at some of the contributing factors affecting smolt production. A more in-depth look into these and other relationships needs to be employed in future reports. The development of a useable limnology database is currently underway for Spiridon Lake and should greatly improve the ability to recognize these complex relationships.

NUTRIENT MONITORING

Mean seasonal water chemistry and nutrient criterion measurements in Spiridon Lake have fluctuated from year to year but concentrations have remained relatively constant over the twenty-two year data set (1988–2009). Despite natural lake fluctuations, the seasonal means for these criteria are within ranges found in oligotrophic lakes.

PRIMARY PRODUCTION

Primary production in Spiridon Lake is measured by determining the phytoplankton standing crop (Chl *a*) during the ice free season. Historically, Spiridon Lake Chl-*a* concentrations have remained relatively stable and within ranges for oligotrophic lakes in Alaska (Schrof and Honnold 2003). Deep barren lakes in Alaska typically have low Chl-*a* levels. Lakes with anadromous sockeye runs have Chl-*a* levels several times greater than those found in Spiridon Lake (Kyle 1996).

TEMPERATURE

Water temperatures are commonly known to play a key role in primary production (Sommer and Lengfellner 2008; Shutter and Ing 1996). Increases in lake temperatures typically contribute to an increase in production at each trophic level, increasing the abundance of phytoplankton, and the potential for increasing zooplankton abundance and juvenile sockeye salmon abundance and body size. Temperature data for Spiridon Lake consisted of measurements taken from two lake sampling stations at each of four to ten sampling events (Appendices A1 and A5).

A cursory review of the available data suggests that warmer spring surface lake temperatures provided favorable conditions that may have increased phytoplankton production in Spiridon Lake, but the relationship is weak (Appendix A5). Further exploration in this area may prove helpful if the scope of phytoplankton sampling is broadened and the frequency of temperature data collection is increased.

Greater lake temperatures can contribute to greater zooplankton abundance (George and Harris 1985). Even with the limited frequency of temperature data collected, some zooplankton species showed similar trends in Spiridon Lake. The cladoceran *Bosmina* increased noticeably in abundance when summer surface temperatures were greater and increased moderately with increased spring bottom temperatures, although every season appeared to have some positive effect. Edmunson and Muzumder (2001) speculated that cladocerans have a greater ability to increase growth and generations when temperatures increase than copepods. The copepod *Diaptomus* increased moderately in abundance when summer surface temperatures were greater. Other species showed no change in abundance when compared to temperature data.

Juvenile sockeye salmon in Alaska lakes have been shown to have increased in size when lake temperatures were greater (Edmundson and Muzumder 2001). Although temperature data were limited, the smolt data from Spiridon Lake provided information for comparisons that can be made to smolt growth and survival. Similar to changes in zooplankton abundance, warmer summer surface temperatures revealed a noticeable increase in survival as observed during the juvenile outmigration (July and August; Appendix A5). Typically, both an increased size of smolt and a decreased lake residence (rearing) time contributed to increased smolt outmigration numbers (Tables 9 and 10). An increased smolt size (condition) was demonstrated by an increased fork length and weight of both age-1. and age-2. smolt. A decrease in residence time can be seen by an increase in the percentage of age-1. and a decrease in the percentage of age-2. smolt outmigrating (Appendix B3).

As in all complex examinations, this is only part of the story. Complete estimates of smolt survival by age by stocking year are available through 2006 (Appendix B3). Estimates of smolt survival by age by stocking year from 2007 through 2009 are awaiting further smolt age class outmigration. While complete estimates of smolt survival cannot be made from 2007 through 2009, inferences can be made by comparing yearly smolt outmigration data. In 2008, zooplankton abundance and lake temperatures were very low, resulting in extremely low growth and likely, increased lake residence time of sockeye smolt (Tables 4, 5, 6, 9, and 10; Appendix A4, A5, and B3). In 2009, zooplankton abundance and lake temperature increased significantly (Tables 4, 5, 6; Appendix A5). Smolt outmigration data from 2009 exhibit an increase in the percentage of age-1. and a decrease in the percentage of age-2. sockeye smolt outmigrating, when compared to 2008 (Tables 9 and 10). It is likely that the low percentage of age-1. sockeye smolt that outmigrated in 2008 resulted in a greater than average hold over of sockeye smolt in the lake, masking much of the change in the smolt age composition in 2009. In addition, the low smolt outmigration numbers of age-1. sockeye salmon in 2008 confirms that low zooplankton abundance and low lake temperatures can have a negative effect on the outmigration of sockeye salmon smolt (Tables 9 and 10; Appendices A5 and B.3).

ZOOPLANKTON MONITORING

Cladocerans

In most oligotrophic lakes in Alaska, such as Spiridon, cladocerans are less abundant than copepods (Kyle 1996). Cladocerans indiscriminate feeding style and lower tolerance to cold water environments are commonly considered the rationale for copepod dominance. Even though cladocerans are less abundant than copepods they are generally considered a preferred food item for juvenile sockeye salmon and are typically exploited at a greater rate (Kyle 1996). This greater exploitation rate would tend to reduce cladoceran abundance and length more quickly than that of copepods (Kyle 1996). This rapid response to predation from juvenile sockeye salmon means they are commonly used as an indicator for predation pressure and is the rationale for a minimum length requirement in the SLMP for *Bosmina* in Spiridon Lake.

The response cladocerans exhibit to juvenile sockeye salmon stocking in barren lakes can be quite variable. In Spiridon Lake, *Bosmina, Daphnia* and *Holopedium* length all exhibit some relationship with the survival or condition of juvenile sockeye salmon. These relationships do not all appear to be a direct result of juvenile sockeye salmon predation on cladocerans. Sweetman (2001) hypothesized that the predatory zooplankton *Cyclops* selectively feeds on *Bosmina* in many Alaska lakes. This selective feeding was demonstrated by *Cyclops* cropping the smaller *Bosmina,* while the length of *Bosmina* remaining in the lake increased (those too large to feed on). This occurrence, Sweetman (2001) postulated, was why larger *Bosmina* occurred in lakes with a higher density of *Cyclops*. This hypothesized predatory relationship likely exists in Spiridon Lake, given that the length of *Bosmina* increased when the abundance of *Cyclops* increased (Tables 5 and 7).

Sockeye salmon were stocked at three life stages in Spiridon Lake; fry, fingerling, and pre-smolt (Table 8). Stocking strategy from 1991 to 2001 and from 2008 to 2009 consisted of fry and/or fry and fingerling releases. During these years, stocking releases averaged nearly 4 million sockeye salmon and zooplankton abundance remained fairly consistent, averaging 6,208 No./m^3 (Appendix A4; 324,134 No./m^2). Juvenile releases from 2002 to 2007 consisted of pre-smolt releases in conjunction with fry or fingerling releases. During these years, stocking releases averaged nearly 2 million, zooplankton abundance declined, averaging 4,406 No./m^3, and cladocerans became the predominate zooplankton (Tables 4 and 8; Appendix A4; 220,469 No./m^2). In 2009, two years after stocking pre-smolt was discontinued, zooplankton abundance and the cladoceran to copepod ratio returned to the historical average.

The pre-smolt example further illustrates these responses; the length of *Bosmina* averaged 0.55 mm before pre-smolt stocking with high *Cyclops* abundance, 0.49 mm during pre-smolt stocking with low *Cyclops* abundance, and 0.55 mm after pre-smolt stocking with high *Cyclops* abundance (Tables 7 and 8). Considering *Bosmina* abundance increased during pre-smolt stocking, and the abundance of *Bosmina* is weakly correlated with the length, weight, and condition of juvenile sockeye salmon, it suggests that *Cyclops* are likely the predominate predator of *Bosmina*.

In general, planktivores tend to select the largest prey they can consume, in many cases reducing zooplankton size (Kyle 1996; Carpenter 1985). As demonstrated above, populations and sizes of planktivores fluctuate, altering the length of zooplankton prey. In Spiridon Lake, the historical mean length of *Daphnia* fluctuates more than other zooplankton taxa and has not returned to mean length since 2002. This may indicate that *Daphnia* are less able to tolerate heavy predation on a sustained basis. Unlike *Bosmina*, it appears that *Daphnia* are selectively fed upon and cropped by juvenile sockeye salmon. This supposition is based on a decrease in the length and biomass of *Daphnia* as the number and length of outmigrating smolt increase (Tables 6, 7, 9 and 10). These relationships use the previous year's length and biomass of *Daphnia,* and the number of outmigrating age-2. smolt; age-1. smolt do not reveal a similar relationship.

The abundance of *Holopedium*, unlike the rest of the zooplankton species, has increased since salmon stocking commenced in Spiridon Lake, reaching nearly fifty percent of total cladoceran biomass in several years (Table 6). Although *Holopedium* have a large gelatinous mass, their body can be of substantial size and beneficial nutrient value (Sterner and Hessen 1994). It appears that age-1. juvenile sockeye salmon selectively feed on *Holopedium* when first stocked and may moderately increase in length, but do not appear to increase in weight (personal communication: Heather Finkle, ADF&G fisheries biologist, Kodiak, Alaska). This indicates *Holopedium* may not be a high-quality food.

Copepods

Zooplankton in Spiridon Lake were predominately composed of copepods (Table 6). Copepods are typically more tolerant to predation and have a greater ability to buffer environmental conditions than cladocerans (Kyle 1996). Their tolerance can be attributed to a greater ability to evade predators, more efficient feeding, the ability to exist in a state of diapause, and a greater adaptation to the cold water environment (Hairston and Munns 1984; Kyle 1996). Conversely, copepods reproduce slower than cladocerans limiting their ability to rebound as quickly (Kyle 1990).

When planktivorous fish predominate, such as large juvenile sockeye salmon, the average length of many zooplankton species tends to decrease as predation increases. Conversely, if predatory zooplankton predominate, such as large *Cyclops*, the average length of many zooplankton species tends to increase when predation increases because they prey upon smaller individuals (Carpenter 1985). As previously mentioned, when the biomass of *Cyclops* increased, the average length of *Bosmina* increased (Tables 5 and 7). Similarly, the length of *Daphnia* increased when the biomass of *Cyclops* increased. While the density of both *Bosmina* and *Daphnia* decreased when *Cyclops* biomass increased, there is a lot of variability. In addition, the length, weight, condition and percent survival of age-1. smolt decreased when *Cyclops* were larger (Tables 7 and 10; Appendix B3). This may indicate that *Cyclops* has the ability to crop *Bosmina* and *Daphnia* but there is not enough evidence to definitively indicate predatory zooplankton dominance.

In Spiridon Lake, *Diaptomus* comprises a minor portion of the zooplankton abundance but is monitored as part of the SLMP criteria. When the density of *Diaptomus* increased, the condition of age-1. and age-2. smolt increased (Tables 5 and 10). Conversely, when the length of *Diaptomus* increased, the condition of age-1. and age-2. smolt decreased. The survival of age-1. smolts were not well correlated with the density of *Diaptomus*. This may indicate that juvenile sockeye salmon feed on smaller *Diaptomus* but it may also indicate that *Diaptomus* flourish when sockeye salmon stocking density is low. Given the strength of several correlations found with *Diaptomus*, further investigation is warranted.

SMOLT MONITORING

Fewer sockeye salmon smolts were expected to outmigrate from Spiridon Lake in 2009. The total smolt outmigration (336,582) was one of the lowest observed since inception of the enhancement project (Tables 1 and 9; Appendix B1 and B3). Lower stocking levels contributed to the lower outmigration (Table 8). Stocking levels for 2007 and 2008 (the predominate stocking years for expected outmigrants) were close to half of the average historically stocked (Table 8). In addition to the lower stocking levels, more juveniles remained in the lake instead of outmigrating (Table 9; Appendix B3). Typically, the outmigration is composed of robust age-1. smolt (Table 9). In 2008 and 2009, the smolt outmigration was predominantly composed of age-2. smolt (Table 9).

Robust smolt body size is indicative of a healthy lake system not exceeding the rearing capacity (Honnold and Schrof 2001). The seasonal average length and weight for age-1. sockeye salmon smolt have been below the historical average for the past five years (three years for age-2. smolt). With the exception of 2009, the condition factor for age-1. sockeye salmon smolt have also been below historical averages (three years for age-2. smolt; Tables 9 and 10). These age, weight, length, and condition data from 2004 to 2009 suggest that the rearing conditions in Spiridon Lake were not optimal for the growth of healthy sockeye salmon smolt (Tables 9 and 10; Appendix B3). The 2009 sockeye salmon smolt outmigration data indicates that the rearing conditions are improving for age-1. smolt. This supposition is based on an increase in the length, weight, and condition of outmigrating sockeye salmon smolt in 2009.

Smolt mortality in the trapping/bypass system was slightly higher than the mean from 1992 through 2008 (2%), at 2.6% in 2009 (Table 9). The increase in mortality was the result of extremely high water and debris blockage caused by didymo (*Didymosphenia geminate*), an invasive species of diatom (personal communication; Greg Watchers, ADF&G fisheries biologist, Kodiak, Alaska; Table 9).

CONCLUSIONS

Spiridon Lake has supported a reasonably steady level of salmon stocking and a fairly robust zooplankton population throughout most of the enhancement project (1990–2009). Recent reductions in zooplankton abundance and lower than average temperatures have resulted in a subsequent decline in juvenile stocking levels, older, smaller, and less fit outmigrating smolt, and a decline in commercial harvest. Survival from stocking to sockeye salmon smolt was below average in 2006 (25.4%; Appendix B3). Survival estimates for sockeye salmon smolt after 2006 cannot be fully addressed until future outmigrations, but the percentage of age-1. sockeye salmon smolt outmigrating indicated a lower than average survival (Appendix B3).

Nutrient and primary production data were all within a normal range for Spiridon Lake and typical for an oligotrophic lake. Based on previous studies and the preliminary findings within this report, lake temperature appears to have been an important influence on primary and secondary production. Given the importance of temperature, and its propensity to fluctuate (yearly and seasonally), finding suitable long-term alternative temperature data would be beneficial.

An increase in Spiridon Lake's temperature in 2009 and reduced juvenile stocking appear to be improving lake rearing conditions. Total zooplankton density and biomass improved greatly from the nearly record low of 2008, reaching average levels. In addition, zooplankton species composition returned to copepod dominance. Although most data from Spiridon Lake indicated improvement, the *Diaptomus:Cyclops* and *Bosmina:Daphnia* density ratios have not returned to historical averages. The 2009 smolt outmigration consisted of near average sockeye smolt growth levels, with larger, heavier, and healthier smolt than the near record low outmigration of 2008. Likewise, sockeye salmon smolt that outmigrated in 2009 outmigrated at a younger age than outmigrants from 2008. While the percentage of age-1. smolt outmigrating was below the historical average, it shows movement back to historical percentages (Appendix B3).

In the interest of furthering understanding, we will continue to explore possible relationships within Spiridon Lake. A preliminary investigation of Spiridon Lake data brings forward some interesting possible zooplankton interactions. Development of a limnology database will assist in the exploration of these and other relationships in Spiridon Lake.

OUTLOOK FOR 2010

In an effort to maintain sufficient zooplankton production, ADF&G recommended sockeye salmon stocking at average historical levels and discontinued the pre-smolt releases of sockeye salmon. While it is not definitive that pre-smolt stocking was detrimental to zooplankton abundance, conservation is warranted. These stocking levels should maintain reasonable grazing pressure on the zooplankton community and allow for improvements in *Daphnia* biomass, cladoceran species composition, average length, weight, and condition of emigrating smolt, and reduce the average age of emigrating smolt. The 2010 projected release of juvenile sockeye salmon into Spiridon Lake will be increased to approximately 3.0 million, 0.4 g fry (Finkle and Byrne 2010). Project activities in 2010 at the Spiridon Lake smolt site (Telrod Creek) are expected to be similar to the 2009 field season. In 2010, the forecasted harvest for Spiridon Lake sockeye salmon is 176,191, with approximately 50% forecasted as harvest within SBSHA.

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TABLES AND FIGURES

Table 1.–Spiridon Lake limnological and fishery monitoring criteria specified in the Spiridon Lake Management Plan (SLMP), and the 2009 results.

	SLMP monitoring criteria	2009 results
Limnology Monitoring		
Mean Total Nitrogen : Total Phosphorous Molar Ratio	148 - 273	248
Mean Total Ammonia (μg/ L)	1.6 - 11.2	4.6
Mean Chlorophyll *a* (Chl *a*) (μg/L)	0.1 - 1.0	0.44
Diaptomus : *Cyclops* Ratio	0.01 - 0.54	0.04
Mean Copepod Biomass (mg/m^3)	3.5 - 21.7	9.6
Bosmina : *Daphnia* Ratio	0.22 - 1.73	5.38
Mean Cladoceran Biomass (mg/m^3)	2.6 - 6.8	6.21
Cladoceran (*Bosmina*) average size (mm)	$\geq$ 0.51	0.54
Stocking		
Sockeye	–[a]	1,475,160
Smolt Monitoring		
Sockeye smolt outmigration estimate	–[a]	327,923
Commercial Harvest from the SBSHA[b]		
Telrod Cove (254–50)		
Sockeye [c]	–[a]	81,725
Coho	–[a]	0
Pink	–[a]	48,921
Chum	–[a]	6,081
Escapement Monitoring		
Spiridon River (254–401)		
Pink (escapement range: 15,000–45,000)	–[a]	13,400
Chum (escapement range: 10,000–30,000)	–[a]	23,500
Coho (escapement range: 4,000–12,000)	–[a]	0

[a] Not a specified criteria in the SLMP
[b] Spiridon Bay Special Harvest Area
[c] Reported harvest includes commercially harvested “home pack”.

Table 2.–Seasonal mean total Kjeldahl nitrogen (TKN), nitrate+nitrite (NO_3+NO_2), total phosphorus (TP) concentrations, and total nitrogen to phosphorus ratio by weight (TN:TP) from the epilimnion (1 m) and hypolimnion (>25 m) of Spiridon Lake, 1988–2009.

Year	Depth	Station	TKN (µg/L)	NO_3+NO_2 (µg/L)	TP (µg/L)	TN:TP Ratio	Mean TN:TP Ratio Epilimnion	Mean TN:TP Ratio Hypolimnion
1988	Epilimnion	1	102.8	220.5	3.8	187		
1988	Hypolimnion	1	94.9	256.9	3.8	205		
1988	Epilimnion	2	100.5	221.3	3.5	204		
1988	Hypolimnion	2	91.4	236.2	4.0	181	195	193
1989	Epilimnion	1	103.4	207.1	3.6	189		
1989	Hypolimnion	1	97.9	242.8	4.2	179		
1989	Epilimnion	2	114.8	197.9	6.1	114		
1989	Hypolimnion	2	104.0	209.8	7.3	95	151	137
1990	Epilimnion	1	92.5	203.4	3.5	188		
1990	Hypolimnion	1	85.3	228.5	3.0	233		
1990	Epilimnion	2	83.2	185.0	2.4	245		
1990	Hypolimnion	2	87.7	187.3	2.5	244	217	238
1991	Epilimnion	1	93.7	234.0	4.9	148		
1991	Hypolimnion	1	87.5	265.1	5.2	150		
1991	Epilimnion	2	91.8	237.0	3.6	201		
1991	Hypolimnion	2	88.6	267.7	3.8	209	175	180
1992	Epilimnion	1	89.6	239.5	3.7	196		
1992	Hypolimnion	1	87.0	258.7	4.9	158		
1992	Epilimnion	2	98.4	235.2	3.6	207		
1992	Hypolimnion	2	83.2	273.4	4.5	175	201	166
1993	Epilimnion	1	93.6	231.6	2.7	267		
1993	Hypolimnion	1	90.7	240.2	3.0	248		
1993	Epilimnion	2	97.0	230.3	2.9	253		
1993	Hypolimnion	2	85.4	247.7	2.5	293	260	271
1994	Epilimnion	1	101.8	204.3	3.2	212		
1994	Hypolimnion	1	97.5	218.1	3.9	178		
1994	Epilimnion	2	105.7	202.1	2.8	245		
1994	Hypolimnion	2	105.6	225.7	3.3	219	228	199
1995	Epilimnion	1	108.8	203.1	3.4	203		
1995	Hypolimnion	1	105.6	241.6	3.4	225		
1995	Epilimnion	2	125.2	213.4	3.9	194		
1995	Hypolimnion	2	108.2	243.1	3.2	244	199	235

-continued-

Table 2.–Page 2 of 3.

Year	Depth	Station	TKN (µg/L)	NO_3+NO_2 (µg/L)	TP (µg/L)	TN:TP Ratio	Mean TN:TP Ratio Epilimnion	Hypolimnion
1996	Epilimnion	1	113.4	183.6	2.7	242		
1996	Hypolimnion	1	90.5	210.8	3.0	222		
1996	Epilimnion	2	105.5	180.2	2.7	236		
1996	Hypolimnion	2	101.1	217.9	4.4	162	239	192
1997	Epilimnion	1	103.6	147.4	3.0	184		
1997	Hypolimnion	1	90.5	191.0	2.8	223		
1997	Epilimnion	2	106.1	168.2	3.1	198		
1997	Hypolimnion	2	107.4	188.3	3.8	171	191	197
1998	Epilimnion	1	138.3	121.5	4.8	120		
1998	Hypolimnion	1	118.4	174.4	4.0	162		
1998	Epilimnion	2	124.6	148.3	3.9	155		
1998	Hypolimnion	2	122.9	171.9	4.0	163	137	163
1999	Epilimnion	1	93.0	188.0	4.0	155		
1999	Hypolimnion	1	92.0	211.4	3.2	213		
1999	Epilimnion	2	103.5	193.4	2.7	240		
1999	Hypolimnion	2	87.9	208.1	3.0	221	197	217
2000	Epilimnion	1	ND	195.5	7.0	ND		
2000	Epilimnion	2	ND	184.0	6.1	ND	ND	ND
2001	Epilimnion	1	101.2	193.8	4.9	133		
2001	Epilimnion	2	ND	189.2	6.7	ND	133	ND
2002	Epilimnion	1	96.7	136.5	3.3	156		
2002	Epilimnion	2	ND	135.0	4.0	ND	156	ND
2003	Epilimnion	1	100.3	203.3	5.7	118		
2003	Epilimnion	2	ND	201.3	3.5	ND	118	ND
2004	Epilimnion	1	98.7	197.3	4.4	149		
2004	Hypolimnion	1	109.9	197.7	4.8	142		
2004	Epilimnion	2	ND	186.4	4.6	ND		
2004	Hypolimnion	2	ND	200.3	10.0	ND	149	142
2005	Epilimnion	1	147.4	139.5	2.7	235		
2005	Hypolimnion	1	40.1	163.7	3.9	116		
2005	Epilimnion	2	ND	142.5	4.1	ND		
2005	Hypolimnion	2	139.8	169.7	5.1	134	235	125

-continued-

Table 2.–Page 3 of 3.

			TKN	NO_3+NO_2	TP	TN:TP	Mean TN:TP Ratio	
Year	Depth	Station	(µg/L)	(µg/L)	(µg/L)	Ratio	Epilimnion	Hypolimnion
2006	Epilimnion	1	255.9	182.7	1.4	694		
2006	Hypolimnion	1	183.1	190.4	1.5	551		
2006	Epilimnion	2	ND	181.8	1.7	ND		
2006	Hypolimnion	2	ND	197.5	2.4	ND	694	551
2007	Epilimnion	1	127.8	171.0	2.3	285		
2007	Hypolimnion	1	108.8	192.8	2.2	304		
2007	Epilimnion	2	ND	165.6	2.1	ND		
2007	Hypolimnion	2	ND	192.0	2.3	ND	285	304
2008	Epilimnion	1	105.8	186.6	2.1	308		
2008	Hypolimnion	1	ND	208.3	2.2	ND		
2008	Epilimnion	2	76.0	178.4	2.7	209		
2008	Hypolimnion	2	ND	183.6	19.3	ND	258	ND
2009	Epilimnion	1	130.0	185.8	3.0	233		
2009	Hypolimnion	1	ND	199.3	4.2	ND		
2009	Epilimnion	2	103.0	193.2	2.5	262		
2009	Hypolimnion	2	ND	213.7	3.1	ND	248	ND
Epilimnion mean 1988-1989:							173	165
Epilimnion mean 1990-2008:							227	227

Table 3.–Summary of seasonal mean epilimnion and hypolimnion, nutrient and algal pigment concentrations by station for Spiridon Lake, 1988–2009.

Year	Station	Depth (m)	Total-P (µg/L)	SD	Total Filterable-P (µg/L)	SD	Filterable reactive-P (µg/L)	SD	Total Kjeldahl nitrogen (µg/L)	SD	Ammonia (µg/L)	SD	Nitrate+nitrite (µg/L)	SD	Chlorophyll *a* (µg/L)	SD
1988	1	1	3.8	1.4	3.0	1.1	2.5	1.2	102.8	11.4	9.9	2.7	220.5	26.0	0.45	0.09
	1	50	3.8	0.6	2.2	0.6	1.7	0.5	94.9	9.0	11.2	5.5	256.9	9.6	0.16	0.06
	2	1	3.5	0.1	2.0	0.6	1.8	0.3	100.5	11.3	7.8	6.6	221.3	11.1	0.40	0.10
	2	50	4.0	0.6	1.9	0.6	1.8	0.5	91.4	9.9	8.6	4.4	236.2	27.5	0.29	0.12
1989	1	1	3.6	0.7	3.7	1.9	3.0	2.2	103.4	7.6	8.5	2.5	207.1	35.4	0.19	0.11
	1	50	4.2	1.0	3.2	1.2	2.4	0.4	97.9	18.6	11.5	7.3	242.8	54.9	0.32	0.18
	2	1	6.1	3.7	2.7	1.0	2.5	0.4	114.8	45.7	9.5	5.2	197.9	61.9	0.18	0.13
	2	50	7.3	7.8	2.7	0.7	2.7	0.7	104.0	40.1	12.5	11.0	209.8	50.4	0.37	0.28
1990	1	1	3.5	1.8	2.4	0.6	2.0	0.8	92.5	16.5	4.9	2.0	203.4	36.8	0.23	0.11
	1	50	3.0	0.7	2.8	0.5	2.0	0.6	85.3	10.9	6.3	2.5	228.5	24.8	0.34	0.21
	2	1	2.4	0.6	4.1	3.2	3.3	2.4	83.2	6.4	4.7	1.7	185.0	79.4	0.24	0.09
	2	50	2.5	0.8	2.8	1.1	2.9	1.9	87.7	12.3	6.6	2.8	187.3	80.1	0.24	0.12
1991	1	1	4.9	5.9	2.8	0.8	2.6	0.9	93.7	7.3	7.6	4.4	234.0	38.1	0.38	0.14
	1	50	5.2	3.7	3.3	2.0	2.8	1.4	87.5	12.9	9.4	4.8	265.1	20.9	0.20	0.09
	2	1	3.6	0.8	4.8	3.3	4.6	3.3	91.8	8.6	8.2	4.5	237.0	29.6	0.35	0.12
	2	50	3.8	1.5	3.6	3.3	3.4	3.2	88.6	7.4	11.3	5.8	267.7	7.7	0.25	0.14
1992	1	1	3.7	0.6	2.1	0.7	1.5	0.5	89.6	10.1	1.5	0.8	239.5	12.3	0.27	0.15
	1	50	4.9	1.4	4.2	3.1	3.7	3.0	87.0	8.0	4.6	3.3	258.7	16.9	0.22	0.07
	2	1	3.6	0.3	2.6	1.4	2.4	1.4	98.4	18.2	1.7	0.6	235.2	25.9	0.27	0.21
	2	50	4.5	0.8	3.1	2.8	2.0	1.1	83.2	24.8	5.3	3.7	273.4	7.7	0.23	0.11
1993	1	1	2.7	0.9	2.2	1.1	1.6	0.8	93.6	11.2	2.4	1.5	231.6	37.6	0.75	0.24
	1	50	3.0	0.9	3.0	4.0	1.8	1.8	90.7	10.8	5.2	3.4	240.2	22.8	0.42	0.20
	2	1	2.9	1.0	3.2	3.5	2.6	3.3	97.0	12.0	1.8	0.5	230.3	41.5	0.77	0.29
	2	50	2.5	0.1	3.2	2.5	2.8	2.5	85.4	3.8	5.4	3.7	247.7	30.6	0.40	0.22

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Table 3.–Page 2 of 3.

Year	Station	Depth (m)	Total-P (µg/L)	SD	Total Filterable-P (µg/L)	SD	Filterable reactive-P (µg/L)	SD	Total Kjeldahl nitrogen (µg/L)	SD	Ammonia (µg/L)	SD	Nitrate+nitrite (µg/L)	SD	Chlorophyll *a* (µg/L)	SD
1994	1	1	3.2	1.3	1.9	1.5	1.5	1.1	101.8	3.9	3.2	4.7	204.3	22.1	0.26	0.21
	1	50	3.9	2.0	1.2	0.2	1.1	0.4	97.5	16.1	6.7	3.6	218.1	18.3	0.21	0.13
	2	1	2.8	0.7	2.2	1.5	1.4	0.9	105.7	12.8	1.6	1.3	202.1	17.2	0.31	0.15
	2	50	3.3	1.2	2.2	1.3	1.9	1.1	105.6	13.2	5.8	2.5	225.7	20.6	0.20	0.07
1995	1	1	3.4	2.2	0.9	0.1	0.9	0.2	108.8	12.3	2.2	1.6	203.1	26.8	0.95	0.49
	1	50	3.4	1.3	1.5	0.3	1.4	0.4	105.6	20.4	3.5	2.4	241.6	6.6	0.58	0.44
	2	1	3.9	2.0	1.2	0.4	1.1	0.2	125.2	24.1	2.2	1.0	213.4	19.8	1.02	0.41
	2	50	3.2	0.9	0.9	0.2	0.9	0.1	108.2	18.6	4.5	3.0	243.1	9.1	0.58	0.45
1996	1	1	2.7	0.6	1.5	0.9	1.0	0.5	113.4	34.1	5.1	2.8	183.6	18.5	0.49	0.16
	1	50	3.0	1.1	1.3	0.7	1.0	0.4	90.5	18.5	9.3	5.0	210.8	9.0	0.51	0.23
	2	1	2.7	0.7	1.4	0.7	1.1	0.3	105.5	20.7	5.6	1.6	180.2	14.4	0.47	0.14
	2	50	4.4	1.7	1.5	0.7	1.5	1.3	101.1	16.9	10.2	4.1	217.9	2.4	0.57	0.33
1997	1	1	3.0	0.6	3.4	3.5	3.5	4.1	103.6	12.0	11.2	5.8	147.4	31.1	0.57	0.35
	1	2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.58	0.37
	1	50	2.8	0.7	1.8	0.4	1.8	0.5	90.5	5.2	11.1	6.3	191.0	19.7	0.38	0.22
	2	1	3.1	0.9	3.2	3.3	3.1	3.2	106.1	11.3	11.2	6.4	168.2	25.2	0.59	0.35
	2	2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.57	0.32
	2	50	3.8	1.5	3.1	1.0	3.2	1.0	107.4	30.3	10.7	6.2	188.3	17.5	0.44	0.24
1998	1	1	4.8	1.6	2.7	1.8	1.7	1.0	138.3	20.5	8.4	6.1	121.5	24.7	0.43	0.25
	1	50	4.0	0.4	1.6	0.8	1.3	0.5	118.4	10.1	10.2	5.4	174.4	19.6	0.14	0.04
	2	1	3.9	1.2	1.5	1.1	1.4	0.6	124.6	10.1	4.9	1.4	148.3	12.2	0.38	0.28
	2	50	4.0	1.7	1.5	0.9	1.5	0.7	122.9	12.0	9.6	4.5	171.9	26.4	0.21	0.12
1999	1	1	4.0	2.5	1.9	0.5	1.5	0.5	93.0	4.8	6.4	2.9	188.0	33.8	0.49	0.30
	1	50	3.2	0.4	1.7	0.7	1.2	0.5	92.0	2.7	6.9	3.8	211.4	6.1	0.15	0.05
	2	1	2.7	0.3	2.3	0.7	1.7	0.4	103.5	14.3	6.2	4.1	193.4	24.0	0.30	0.22
	2	50	3.0	0.6	2.3	1.6	1.7	1.4	87.9	15.3	11.2	6.0	208.1	10.1	0.25	0.14

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Table 3.–Page 3 of 3.

Year	Station	Depth (m)	Total-P (µg/L)	SD	Total Filterable-P (µg/L)	SD	Filterable reactive-P (µg/L)	SD	Total Kjeldahl nitrogen (µg/L)	SD	Ammonia (µg/L)	SD	Nitrate+nitrite (µg/L)	SD	Chlorophyll *a* (µg/L)	SD
2000	1	1	7.0	4.5	3.4	3.8	2.3	2.2	ND	–	8.7	8.6	195.5	1.8	0.58	0.14
	2	1	6.1	8.7	3.3	4.6	2.0	2.0	ND	–	7.5	8.0	184.0	15.7	0.77	0.18
2001	1	1	4.9	3.3	3.5	2.1	1.9	2.0	101.2	8.0	4.6	4.7	193.8	6.7	0.60	0.30
	2	1	6.7	5.1	3.5	3.3	2.7	3.5	ND	–	2.1	1.3	189.2	7.3	0.60	0.10
2002	1	1	3.3	2.6	1.5	0.9	3.0	1.9	96.7	14.5	5.0	2.3	136.5	7.9	0.32	0.00
	2	1	4.0	1.9	1.3	1.3	1.9	1.0	ND	–	3.4	1.7	135.0	21.2	0.45	0.18
2003	1	1	5.7	0.8	2.8	3.4	2.6	1.7	100.3	9.9	2.6	2.1	203.3	36.7	0.70	0.40
	2	1	3.5	0.7	1.4	1.1	3.6	0.8	ND	–	1.9	2.0	201.3	22.1	0.60	0.30
2004	1	1	4.4	2.9	0.9	0.9	1.5	1.1	98.7	47.6	6.8	2.1	197.3	19.1	0.60	0.25
	2	1	4.6	4.4	2.0	3.9	2.0	0.9	ND	–	7.2	1.3	186.4	19.6	0.82	0.71
2005	1	1	2.7	1.2	1.8	1.5	0.5	1.2	147.4	135.4	4.7	1.6	139.5	28.2	0.51	0.20
	2	1	4.1	0.7	1.0	0.9	0.5	0.7	152.6	62.0	4.9	2.0	142.5	15.6	0.52	0.04
2006	1	1	1.4	1.3	1.7	0.2	1.0	0.5	255.9	166.5	7.0	1.4	182.7	15.3	0.68	0.25
	2	1	1.7	1.3	1.5	0.2	0.9	0.4	ND	–	7.2	1.5	181.8	17.2	0.74	0.23
2007	1	1	2.3	0.6	1.0	0.7	0.4	0.1	127.8	27.8	5.1	1.5	171.0	23.2	0.64	0.39
	2	1	2.1	0.9	0.8	0.4	0.6	0.3	ND	–	5.8	3.4	165.6	25.6	0.58	0.42
2008	1	1	2.1	0.4	0.9	0.3	1.7	1.6	105.8	68.3	4.4	1.0	186.6	20.3	0.71	0.56
	2	1	2.7	0.4	1.1	0.8	1.0	1.1	76.0	56.2	4.6	1.6	178.4	13.5	0.64	0.39
2009	1	1	3.0	1.2	0.5	0.5	1.7	0.9	130.0	58.4	4.4	1.3	185.8	16.5	0.54	0.31
	2	1	2.5	1.2	1.1	1.1	1.8	0.7	103.0	57.1	4.8	1.6	193.2	14.4	0.34	0.22
Mean 1 m 1988-1989:			3.8	0.7	2.2	0.7	1.9	0.6	97.4	10.4	9.4	4.8	233.7	18.5	0.32	0.09
Mean 1 m 1990-2008:			3.9	2.0	2.5	1.8	2.2	1.5	103.9	29.6	5.9	3.2	205.1	27.2	0.47	0.22

Note: The epilimnion consists of samples taken from a depth of 1 meter and the hypolimnion consists of samples taken from a depth of 50 meters.

Table 4.–Summary of Spiridon Lake cladoceran and copepod weighted mean density, biomass, and their comparative ratios, 1988-2009.

	Cladoceran		Copepod		Total		Cladoceran to Copepod ratios [a]	
	Density	Biomass	Density	Biomass	Density	Biomass	Abundance	Biomass
Year	No./m^3	mg/m^3	No./m^3	mg/m^3	No./m^3	mg/m^3	Ratio	Ratio
1988	1,120	5.30	4,006	11.70	5,126	17.00	0.28 :1	0.45 :1
1989	1,308	4.90	9,826	15.80	11,134	20.70	0.13 :1	0.31 :1
1990	1,055	5.10	6,361	17.70	7,416	22.80	0.17 :1	0.29 :1
1991	834	3.40	8,862	18.80	9,696	22.20	0.09 :1	0.18 :1
1992	980	4.50	6,996	21.70	7,976	26.20	0.14 :1	0.21 :1
1993	878	2.94	5,616	10.30	6,494	13.24	0.16 :1	0.29 :1
1994	1,517	4.70	4,977	10.00	6,494	14.70	0.30 :1	0.47 :1
1995	1,589	6.40	4,538	12.00	6,127	18.40	0.35 :1	0.53 :1
1996	1,180	5.20	7,762	17.10	8,942	22.30	0.15 :1	0.30 :1
1997	1,531	6.70	2,477	6.30	4,008	13.00	0.62 :1	1.06 :1
1998	1,715	6.80	7,262	10.50	8,977	17.30	0.24 :1	0.65 :1
1999	726	2.60	1,450	3.50	2,176	6.10	0.50 :1	0.74 :1
2000	1,580	4.95	7,526	9.81	9,106	14.76	0.21 :1	0.50 :1
2001	1,752	7.55	1,467	4.43	3,219	11.98	1.19 :1	1.70 :1
2002	2,211	11.34	5,045	9.87	7,256	21.21	0.44 :1	1.15 :1
2003	2,785	6.76	4,160	7.13	6,945	13.89	0.67 :1	0.95 :1
2004 [b]	1,679	3.56	1,567	3.00	3,246	6.56	1.07 :1	1.19 :1
2005 [b]	3,329	10.15	1,671	2.73	5,000	12.88	1.99 :1	3.72 :1
2006 [c]	1,453	5.10	279	0.90	1,732	6.00	5.21 :1	5.67 :1
2007	1,688	4.00	567	1.72	2,255	5.72	2.98 :1	2.33 :1
2008	1,485	4.16	639	2.17	2,124	6.33	2.32 :1	1.92 :1
2009	1,499	6.21	3865	9.59	5,364	15.80	0.39 :1	0.65 :1
Mean 88-89	1,214	5.10	6,916	13.75	8,130	18.85	0.18 :1	0.37 :1
Mean 90-08	1,577	5.57	4,170	8.93	5,747	14.50	0.38 :1	0.62 :1

[a] Values based on seasonal mean density and biomass.

[b] Values in 2004 were derived from 10 sampling dates, in 2005 from 8 sampling dates.

[c] Values include five sampling dates from each station only (5/23 or 5/16, 6/27, 8/1, 9/5, and 9/23).

Table 5.–Spiridon Lake weighted mean copepod density and biomass by species and the *Diaptomus* to *Cyclops* abundance ratio, 1988–2009.

Year	Number of Samples	*Epischura* Density No./m^3	*Epischura* Biomass mg/m^3	*Diaptomus* Density No./m^3	*Diaptomus* Biomass mg/m^3	*Cyclops* Density No./m^3	*Cyclops* Biomass mg/m^3	Totals Density No./m^3	Totals Biomass mg/m^3	*Diaptomus*: *Cyclops* Ratio [a]
1988	4	0	0.00	1,067	4.86	2,939	6.84	4,006	11.70	0.36 :1
1989	5	0	0.00	2,199	6.70	7,627	9.10	9,826	15.80	0.29 :1
1990	5	0	0.00	2,228	9.40	4,134	8.30	6,361	17.70	0.54 :1
1991	7	0	0.00	2,276	7.50	6,587	11.30	8,862	18.80	0.35 :1
1992	6	0	0.00	504	3.10	6,492	18.60	6,996	21.70	0.08 :1
1993	6	5	0.00	221	1.10	5,395	9.20	5,621	10.30	0.04 :1
1994	6	0	0.00	155	0.80	4,822	9.20	4,977	10.00	0.03 :1
1995	6	0	0.00	266	2.50	4,272	9.50	4,538	12.00	0.06 :1
1996	6	0	0.00	69	0.40	7,693	16.70	7,762	17.10	0.01 :1
1997	6	0	0.00	64	0.50	2,413	5.80	2,477	6.30	0.03 :1
1998	5	0	0.00	163	0.90	7,099	9.60	7,262	10.50	0.02 :1
1999	5	0	0.00	97	0.50	1,353	3.00	1,450	3.50	0.07 :1
2000	5	133	0.21	61	0.35	7,332	9.25	7,526	9.81	0.01 :1
2001	5	46	0.07	95	0.93	1,326	3.43	1,467	4.43	0.07 :1
2002	5	81	0.09	459	2.50	4,506	7.28	5,045	9.87	0.10 :1
2003	4	381	0.44	593	2.60	3,186	4.09	4,160	7.13	0.19 :1
2004	10	57	0.08	100	0.65	1,410	2.27	1,567	3.00	0.07 :1
2005	8	36	0.04	45	0.21	1,590	2.48	1,671	2.73	0.03 :1
2006 [b]	5	3	0.00	17	0.10	259	0.80	279	0.90	0.07 :1
2007	5	11	0.01	56	0.30	501	1.41	567	1.72	0.11 :1
2008	5	54	0.19	24	0.15	561	1.83	639	2.17	0.04 :1
2009	5	5	0.01	154	1.22	3,706	8.36	3,865	9.59	0.04 :1
Mean 1988-1989:	5	0	0.00	1,633	5.78	5,283	7.97	6,916	13.75	0.31 :1
Mean 1990-2008:	6	42	0.06	394	1.82	3,733	7.05	4,170	8.93	0.11 :1

[a] Values based on mean density.

[b] Values include five sampling dates from each station only (5/23 or 5/16, 6/27, 8/1, 9/5, and 9/23).

Table 6.–Summary of the Spiridon Lake weighted mean density and biomass of cladocerans by species and the *Bosmina* to *Daphnia* abundance ratio, 1988–2009.

Year	Number of Samples	*Bosmina* Density No./m^3	*Bosmina* Biomass mg/m^3	*Daphnia* Density No./m^3	*Daphnia* Biomass mg/m^3	*Holopedium* Density No./m^3	*Holopedium* Biomass mg/m^3	Totals Density No./m^3	Totals Biomass mg/m^3	*Bosmina*: *Daphnia* ratio [a]
1988	4	724	2.60	381	2.60	15	0.10	1,120	5.30	1.90 :1
1989	5	759	2.20	441	1.90	108	0.80	1,308	4.90	1.72 :1
1990	5	424	1.40	601	3.60	30	0.10	1,055	5.10	0.70 :1
1991	7	144	0.40	662	2.90	28	0.10	834	3.40	0.22 :1
1992	6	298	1.00	614	3.00	68	0.50	980	4.50	0.49 :1
1993	6	324	0.90	479	1.44	75	0.60	878	2.94	0.68 :1
1994	6	561	1.50	801	2.00	155	1.20	1,517	4.70	0.70 :1
1995	6	599	1.50	591	1.60	399	3.30	1,589	6.40	1.01 :1
1996	6	571	1.90	427	1.60	182	1.70	1,180	5.20	1.34 :1
1997	6	652	1.80	526	2.20	353	2.70	1,531	6.70	1.24 :1
1998	5	474	1.20	915	4.40	326	1.20	1,715	6.80	0.52 :1
1999	5	374	1.20	216	0.70	136	0.70	726	2.60	1.73 :1
2000	5	855	2.04	442	1.19	282	1.72	1,580	4.95	1.94 :1
2001	5	664	1.88	793	2.50	294	3.16	1,752	7.55	0.84 :1
2002	5	714	2.08	485	2.36	1,012	6.90	2,211	11.34	1.47 :1
2003	4	1,671	3.17	826	1.67	288	1.92	2,785	6.76	2.02 :1
2004	10	638	1.36	999	2.02	42	0.18	1,679	3.56	0.64 :1
2005	8	1,745	4.09	1,122	1.89	462	4.17	3,329	10.15	1.56 :1
2006 [b]	5	516	1.10	559	0.90	378	3.10	1,453	5.10	0.92 :1
2007	5	653	1.30	747	1.23	288	1.47	1,688	4.00	0.87 :1
2008	5	592	1.72	880	2.27	13	0.17	1,485	4.16	0.67 :1
2009	5	947	2.67	176	0.43	376	3.11	1,499	6.21	5.38 :1
Mean 1988-1989:	5	741	2.40	411	2.25	62	0.45	1,214	5.10	1.80 :1
Mean 1990-2008:	6	656	1.66	668	2.08	253	1.84	1,577	5.57	0.98 :1

[a] Values based on mean density.

[b] Values include five sampling dates from each station only (5/23 or 5/16, 6/27, 8/1, 9/5, and 9/23).

Table 7.–Seasonal weighted mean lengths (mm) of zooplankton taxa in Spiridon Lake, 1988–2009.

Year	*Diaptomus*	*Cyclops*	*Bosmina*	*Daphnia*	*Holopedium*
1988	1.02	0.82	0.61	1.20	0.73
1989	0.89	0.60	0.56	0.96	0.82
1990	1.00	0.76	0.59	1.10	0.69
1991	0.94	0.70	0.55	0.99	0.76
1992	1.13	0.91	0.60	1.01	0.91
1993	1.06	0.70	0.51	0.80	0.83
1994 [a]	1.09	0.75	0.55	0.75	0.85
1995 [a]	1.30	0.79	0.51	0.78	0.83
1996 [a]	0.99	0.78	0.58	0.92	0.91
1997 [a]	1.26	0.82	0.54	1.00	0.84
1998	1.09	0.63	0.52	0.90	0.58
1999	1.06	0.78	0.58	0.92	0.63
2000	1.14	0.61	0.51	0.79	0.76
2001	1.34	0.85	0.55	0.84	0.97
2002	1.12	0.69	0.55	1.02	0.80
2003	1.01	0.62	0.45	0.68	0.80
2004 [b]	1.14	0.70	0.50	0.72	0.68
2005 [b]	1.00	0.67	0.50	0.62	0.79
2006 [b]	1.10	0.93	0.47	0.60	0.86
2007	1.13	0.88	0.46	0.61	0.73
2008	1.14	0.95	0.55	0.76	0.96
2009	1.24	0.80	0.54	0.74	0.88
Mean 1988-1989:	0.95	0.71	0.58	1.08	0.77
Mean 1990-2008:	1.11	0.77	0.53	0.82	0.80

[a] From 1994 to 1997 average lengths were derived from samples collected at 4 sampling stations. In most years, average lengths were derived from samples collected at 2 sampling stations.

[b] From 2004 to 2006 average lengths were derived from a subset of 5 sample dates, not the complete set of 8–10 samples that were collected. Only 5 sample dates were used for average length calculations to maintain interannual comparability.

Table 8.–Sockeye salmon stocking numbers, life stage, size and release date, by year into Spiridon Lake, 1990–2009.

	Fry			Fingerling			Pre-Smolt			
	Date Stocked	Number	Size (g)	Date Stocked	Number	Size (g)	Date Stocked	Number	Size (g)	Total Stocked
1990	ND	249,346	ND		0			0		249,346
1991	7-Jul	3,480,000	0.3		0			0		3,480,000
1992	20-Jun	2,200,000	0.2		0			0		2,200,000
1993	9-Jun	4,246,000	0.2		0			0		4,246,000
1994	24-May	4,400,000	0.2		0			0		5,676,000
	9-Jun	1,276,000	0.2							
1995	26-Jun	2,813,000	0.3	5-Jul	1,786,000	0.4		0		4,599,000
1996	21-May	1,100,000	0.2	26-Jun	3,744,000	0.4		0		4,844,000
1997	28-Jun	4,200,000	0.2	24-Jul	1,200,000	0.5		0		6,700,000
	12-Jul	1,300,000	0.3							
1998	18-Jun	784,000	0.4	13-Jul	2,556,000	0.9		0		3,340,000
1999	18-Jun	600,000	0.3	8-29 Jul	2,160,000	1.0		0		3,564,000
				2-17 Jul	804,000	2.0				
2000	25-May	535,000	0.3	23-Aug	507,100	3.0		0		4,397,100
	11-Jun	3,355,000	0.4							
2001		0		21-Jun	1,700,600	0.8		0		1,700,600
2002		0		30-Jul	366,000	1.2	4-Oct	586,900	8.5	952,900
2003		0		29-Jun	730,744	1.2	9-Oct	686,775	11.8	1,417,519
2004		0		19-Jun	2,008,205	0.5	5-7 Oct	501,220	11.5	2,797,644
				16-Aug	288,219	4.1				

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Table 8.–Page 2 of 2.

	Fry			Fingerling			Pre-Smolt			
	Date Stocked	Number	Size (g)	Date Stocked	Number	Size (g)	Date Stocked	Number	Size (g)	Total Stocked
2005		0		23-Jun	693,176	0.8	2-3 Oct	508,492	8.4	1,201,668
2006	23-24 Jun	2,765,088	0.4		0		5-6 Oct	431,424	9.9	3,196,512
2007	17-Jun	1,559,868	0.3		0		28-Sep	250,243	5.7	1,810,111
2008	27-Jun	1,049,809	0.3		0			0		1,049,809
2009		0		8-Jul	1,560,000	0.5		0		1,475,160
Mean 1991-2008		1,981,320			1,030,225			164,725		3,176,270

Note: Life stages are determined by emergent weight (g). Two times emergent weight is called a fingerling and 20 times emergent weight is called a pre-smolt. Release dates typically spanned several days due to the large number of juveniles to be released and weather delays. Therefore, weights were averaged for multiple release dates.

Table 9.–Spiridon Lake sockeye salmon total smolt emigration and mortality estimates by year and age, 1992–2009.

Year	Number and Proportions of Smolt by Age Class 1.	2.	3.	Total Smolt	Total Mortality	Number and Proportions of Live Smolt by Age Class 1.	2.	3.	Total Live Smolt
1992	1,466,995	17,826	0	1,484,821	87,169	1,380,321	17,331	0	1,397,652
	98.8%	1.2%	0.0%	100.0%	5.9%	98.8%	1.2%	0.0%	100.0%
1993	260,115	85,443	0	345,558	15,433	249,784	80,341	0	330,125
	75.3%	24.7%	0.0%	100.0%	4.5%	75.7%	24.3%	0.0%	100.0%
1994	599,717	244,360	6,271	850,348	3,123	597,502	243,464	6,259	847,225
	70.5%	28.7%	0.7%	100.0%	0.4%	70.5%	28.7%	0.7%	100.0%
1995	314,604	299,556	831	614,992	21,030	304,326	288,822	813	593,961
	51.2%	48.7%	0.1%	100.0%	3.4%	51.2%	48.6%	0.1%	100.0%
1996	918,540	135,414	1,232	1,055,186	23,120	897,762	133,097	1,207	1,032,066
	87.1%	12.8%	0.1%	100.0%	2.2%	87.0%	12.9%	0.1%	100.0%
1997	654,293	237,492	2,934	894,719	25,551	635,650	230,685	2,833	869,168
	73.1%	26.5%	0.3%	100.0%	2.9%	73.1%	26.5%	0.3%	100.0%
1998	529,726	216,923	301	746,950	21,321	514,606	210,731	292	725,629
	70.9%	29.0%	0.0%	100.0%	2.9%	70.9%	29.0%	0.0%	100.0%
1999	812,267	123,458	373	936,118	37,331	779,875	118,534	358	898,787
	86.8%	13.2%	0.0%	100.0%	4.0%	86.8%	13.2%	0.0%	100.0%
2000	792,029	493,529	5,133	1,290,692	4,384	788,909	492,275	5,122	1,286,306
	61.4%	38.2%	0.4%	100.0%	0.3%	61.3%	38.3%	0.4%	100.0%

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Table 9.–Page 2 of 2.

Year	Number and Proportions of Smolt by Age Class 1.	2.	3.	Total Smolt	Total Mortality	Number and Proportions of Live Smolt by Age Class 1.	2.	3.	Total Live Smolt
2001	1,093,246	442,975	0	1,536,221	7,305	1,087,695	441,221	0	1,528,916
	71.2%	28.8%	0.0%	100.0%	0.5%	71.1%	28.9%	0.0%	100.0%
2002	441,964	92,484	0	534,448	12,523	431,542	90,384	0	521,925
	82.7%	17.3%	0.0%	100.0%	2.3%	82.7%	17.3%	0.0%	100.0%
2003	228,857	34,854	914	264,624	1,777	227,363	34,696	789	262,847
	86.5%	13.2%	0.3%	100.0%	0.7%	86.5%	13.2%	0.3%	100.0%
2004	540,748	36,882	1,274	578,904	1,249	539,582	36,804	1,269	577,655
	93.4%	6.4%	0.2%	100.0%	0.2%	93.4%	6.4%	0.2%	100.0%
2005	1,368,763	48,326	4,264	1,421,353	11,979	1,357,702	47,636	4,036	1,409,374
	96.3%	3.4%	0.3%	100.0%	0.8%	96.3%	3.4%	0.3%	100.0%
2006	471,241	94,932	0	566,173	1,214	470,231	94,728	0	564,959
	83.2%	16.8%	0.0%	100.0%	0.2%	83.2%	16.8%	0.0%	100.0%
2007	387,179	96,795	0	483,974	4,563	383,529	95,882	0	479,411
	80.0%	20.0%	0.0%	100.0%	0.9%	80.0%	20.0%	0.0%	100.0%
2008	117,370	426,010	0	543,380	4,876	116,491	422,013	0	538,504
	21.6%	78.4%	0.0%	100.0%	0.9%	21.6%	78.4%	0.0%	100.0%
2009	132,681	203,901	0	336,582	8,659	129,267	198,656	0	327,923
	39.4%	60.6%	0.0%	100.0%	2.6%	39.4%	60.6%	0.0%	100.0%
Average	646,921	183,956	1,384	832,262	16,703	633,110	181,097	1,352	815,559
1992-2008	77.7%	22.1%	0.2%	100.0%	2.0%	77.6%	22.2%	0.2%	100.0%

Note: Age percentages may not match those in Table 10. Values in Table 9 have been adjusted to account for non-aged emigrating smolt. Percentages in Table 9 may not add up exactly due to rounding.

Table 10.–Mean length, weight, and condition coefficient by age of sockeye salmon smolt captured by trap emigrating from Spiridon Lake, 1991–2009.

	Age-1.						Age-2.						Age-3.					
Year	N [a]	N [b]	% Captured	Length (mm)	Weight (g)	Condition (K)	N [a]	N [b]	% Captured	Length (mm)	Weight (g)	Condition (K)	N [a]	N [b]	% Captured	Length (mm)	Weight (g)	Condition (K)
1991	596	596	100.0	127	19.3	1.08	0	0	0.0	–	–	–	0	0	0.0	–	–	–
1992	1,393	1,389	98.8	115	12.7	0.81	16	14	1.1	183	58.9	0.80	0	0	0.0	–	–	–
1993	817	493	66.8	116	13.4	0.83	404	240	33.0	155	33.8	0.88	2	2	0.2	178	50.7	0.90
1994	1,477	929	73.5	106	9.3	0.78	526	344	26.2	152	28.5	0.79	6	4	0.3	254	145.8	0.88
1995	1,697	999	60.9	104	9.2	0.81	1,081	667	38.8	138	25.1	0.95	6	5	0.2	244	102.8	0.84
1996	2,224	1,573	76.1	109	10.3	0.79	694	513	23.7	141	20.7	0.73	6	5	0.2	221	85.6	0.77
1997	1,428	876	66.2	102	8.6	0.80	720	441	33.4	137	20.6	0.80	11	6	0.5	169	41.9	0.81
1998	2,205	1,496	77.4	93	6.3	0.76	727	414	22.5	127	15.4	0.75	3	0	0.1	–	–	–
1999 [c]	1,452	799	73.6	95	7.0	0.80	518	336	26.3	122	14.1	0.78	2	1	0.1	126	15.0	0.75
2000	2,263	1,700	81.1	94	6.8	0.79	507	325	18.2	132	18.5	0.80	22	8	0.8	142	22.4	0.77
2001	2,037	2,037	80.1	104	8.8	0.78	506	506	19.9	136	20.2	0.79	0	0	0.0	–	–	–
2002	1,716	1,716	86.6	118	12.7	0.77	266	266	13.4	155	30.2	0.80	0	0	0.0	–	–	–
2003	1,226	1,197	80.0	131	20.4	0.89	288	277	18.8	165	42.4	0.87	19	19	1.2	168	42.7	0.84
2004	1,325	1,325	89.0	127	16.8	0.80	160	160	10.8	184	51.3	0.80	3	3	0.2	227	97.7	0.84
2005	1,068	1,068	88.6	106	9.6	0.79	119	119	9.9	178	51.1	0.83	18	18	1.5	195	61.8	0.84
2006	871	871	88.1	107	9.7	0.75	118	118	11.9	158	32.6	0.82	0	0	0.0	–	–	–
2007	1,063	1,063	81.6	101	8.4	0.77	240	240	18.4	139	21.0	0.80	0	0	0.0	–	–	–
2008	371	371	46.8	92	5.4	0.70	422	422	53.2	127	15.6	0.75	0	0	0.0	–	–	–
2009	690	690	65.5	101	8.6	0.82	363	363	34.5	137	20.8	0.77	0	0	0.0	–	–	–
Average 1991-2008			78.6	108	10.8	0.81			21.1	149	29.4	0.81			0.3	192	66.6	0.82

Note: Age percentages may not match those in Table 9. Values in Table 9 have been adjusted to account for non-aged emigrating smolt.

[a] The number of smolt aged.

[b] The number of smolt sampled for length, weight, and condition.

[c] One smolt sampled was age 0. and was 96 mm; 6.6 g; 0.75 K.

Table 11.–Commercial harvest of salmon by species and day in the Spiridon Bay Special Harvest Area (statistical area 254-50), 2009.

Date [a]	Sockeye [b]	Coho	Pink	Chum	Total
21-Jun	3,341	0	3	27	3,371
22-Jun	1,580	0	0	16	1,596
23-Jun	128	0	2	0	130
24-Jun	2,451	0	5	0	2,456
25-Jun	753	0	2	20	775
26-Jun	4,296	0	46	0	4,342
27-Jun	1,099	0	43	10	1,152
28-Jun	2,097	0	119	7	2,223
29-Jun	641	0	32	17	690
30-Jun	4,395	0	285	5	4,685
1-Jul	1,341	0	157	0	1,498
2-Jul	6,513	0	643	110	7,266
3-Jul	3,439	0	824	50	4,313
4-Jul	5,201	0	606	93	5,900
5-Jul	3,125	0	347	32	3,504
6-Jul	3,917	0	627	73	4,617
7-Jul	7,094	0	1,426	118	8,638
8-Jul	3,172	0	1,917	532	5,621
9-Jul	1,083	0	597	363	2,043
10-Jul	1,126	0	766	106	1,998
11-Jul	1,848	0	1,634	385	3,867
12-Jul	968	0	912	137	2,017
13-Jul	1,067	0	1,100	205	2,372
14-Jul	2,538	0	3,974	536	7,048
15-Jul	760	0	1,415	353	2,528
16-Jul	529	0	378	453	1,360
17-Jul	664	0	955	73	1,692
19-Jul	1,414	0	2,130	1,785	5,329
20-Jul	1,695	0	2,772	3,687	8,154
21-Jul	1,014	0	3,429	3,739	8,182
28-Jul	2,144	0	4,630	6,575	13,349
29-Jul	2,046	0	4,994	15,906	22,946
30-Jul	592	0	1,027	2,141	3,760
31-Jul	768	0	1,825	3,658	6,251
1-Aug	202	0	362	871	1,435
3-Aug	459	0	871	598	1,928
4-Aug	714	0	1,893	1,376	3,983
5-Aug	249	0	568	550	1,367
Total	81,244	0	48,921	6,081	136,246

[a] Harvest dates with confidential data (less than three landings) are not included in the table.

[b] Harvest does not include "home pack", only sockeye salmon sold.

Table 12.–Commercial harvest of salmon by species and year in the Spiridon Bay Special Harvest Area (statistical area 254-50), 1994–2009.

Year	Sockeye	Coho	Pink	Chum
1994	130,891	4,584	32,331	2,291
1995	11,889	2,194	46,422	2,169
1996	164,114	3,622	44,701	4,684
1997	66,480	4,889	54,236	2,575
1998	90,447	2,211	103,715	4,812
1999	192,773	2,149	61,004	13,700
2000	81,931	565	108,254	13,070
2001	59,733	345	70,883	12,885
2002	201,534	2,331	222,860	8,189
2003	259,714	66	73,549	10,643
2004	75,775	12	23,644	2,105
2005	59,494	0	33,254	2,106
2006	36,467	7	29,281	1,099
2007	70,250	15	52,638	3,233
2008	154,575	33	67,214	7,627
2009 [a]	81,725	0	48,921	6,081
Mean 1994-2008	110,404	1,535	68,266	6,079

[a] Harvest includes “home pack”.

Table 13.–Estimated age composition of adult sockeye salmon harvest from Spiridon Bay Special Harvest Area (statistical area 254-50), 1994–2009.

	Sample		Ages													
Year	Size		0.2	1.1	0.3	1.2	2.1	1.3	0.4	2.2	2.3	3.1	3.2	1.4	2.4	Total [a]
1994	1,329	Percent	0.0	0.1	0.0	99.5	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
		Numbers	0	149	0	114,624	356	30	0	21	9	0	0	0	0	115,189
1995	1,313	Percent	0.1	19.9	0.1	60.2	1.9	4.9	0.0	11.6	1.3	0.0	0.0	0.0	0.0	100.0
		Numbers	19	6,312	37	19,089	595	1,563	0	3,667	409	0	0	0	0	31,691
1996	1,875	Percent	0.0	1.8	0.0	79.0	4.6	0.2	0.0	14.3	0.0	0.1	0.0	0.0	0.0	100.0
		Numbers	0	2,846	0	128,123	7,448	303	0	23,192	0	111	97	0	0	162,120
1997	1,703	Percent	0.0	2.8	0.0	62.6	2.8	2.4		29.3	0.0	0.0	0.0	0.0	0.0	99.9
		Numbers	0	1,795	0	40,359	1,824	1,558	0.0	18,908	25	7	7	0	0	64,483
1998	1,943	Percent	0.0	4.2	0.0	81.8	2.0	0.6	0.0	10.7	0.5	0.0	0.1	0.0	0.0	99.9
		Numbers	0	3,726	0	72,354	1,785	543	0	9,448	485	0	111	0	0	88,452
1999	2,345	Percent	0.0	0.4	0.0	47.8	0.2	32.7	0.0	17.4	1.5	0.0	0.1	0.0	0.0	100.1
		Numbers	0	689	86	91,129	298	62,405	0	33,167	2,836	0	168	0	0	190,778
2000	1,997	Percent	0.0	0.1	0.1	71.5	0.2	3.0	0.0	18.3	6.6	0.0	0.1	0.1	0.0	100.0
		Numbers	9	122	60	58,559	176	2,419	0	14,987	5,446	0	110	42	0	81,930
2001	1,534	Percent	0.0	1.1	0.1	58.5	3.4	17.2	0.0	19.0	0.7	0.0	0.0	0.0	0.0	100.0
		Numbers	0	674	51	34,921	2,022	10,300	28	11,334	391	0	0	7	7	59,735
2002	1,572	Percent	0.0	0.2	0.0	36.1	2.0	35.8	0.0	24.7	1.0	0.0	0.1	0.1	0.0	100.0
		Numbers	0	466	59	71,962	4,077	71,479	0	49,330	1,909	0	119	139	0	199,539
2003	1,782	Percent	0.0	0.3	0.0	46.3	0.0	26.9	0.0	21.2	5.1	0.0	0.0	0.1	0.0	100.0
		Numbers	0	849	0	120,346	68	69,908	0	55,122	13,201	0	68	151	0	259,714

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Table 13.–Page 2 of 2.

Year	Sample Size		Ages 0.2	1.1	0.3	1.2	2.1	1.3	0.4	2.2	2.3	3.1	3.2	1.4	2.4	Total[a]
2004	1,761	Percent	0.0	0.1	0.0	27.8	0.0	54.6	0.0	7.8	9.4	0.0	0.0	0.2	0.0	100.0
		Numbers	0	101	29	21,029	22	41,349	0	5,880	7,156	0	29	160	0	75,775
2005	1,272	Percent	0.0	7.5	0.0	38.3	0.0	52.2	0.0	1.5	0.3	0.0	0.0	0.0	0.0	100.0
		Numbers	0	4,475	0	22,812	25	31,081	0	909	193	0	0	0	0	59,494
2006	999	Percent	0.0	0.4	0.0	83.0	0.4	11.9	0.0	3.0	0.3	0.0	0.0	1.0	0.0	100.0
		Numbers	0	157	0	30,277	141	4,354	0	1,082	92	0	0	363	0	36,467
2007	1,203	Percent	0.0	0.0	0.0	62.2	0.0	36.5	0.0	0.9	0.4	0.0	0.0	0.0	0.0	100.0
		Numbers	0	0	0	43,696	0	25,641	0	632	281	0	0	0	0	70,250
2008	1,482	Percent	0.0	0.0	0.0	19.4	0.0	62.6	0.0	16.0	1.6	0.0	0.0	0.4	0.0	100.0
		Numbers	0	0	0	29,968	0	96,701	0	24,716	2,472	0	0	281	0	154,475
2009[a]	1,206	Percent	0.0	0.4	0.4	20.0	1.2	48.6	0.0	20.8	8.3	0.0	0.1	0.1	0.0	100.0
		Numbers	0	366	339	16,364	958	39,746	0	17,014	6,769	0	64	104	0	81,725
1994-2008	1,651	Percent	0.0	1.4	0.0	53.9	1.2	25.7	0.0	15.6	2.2	0.0	0.0	0.0	0.0	100.0
Average		Numbers	2	1,586	23	62,069	1,335	29,663	2	17,951	2,487	8	51	56	1	115,233

Note: Totals may not add up exactly due to rounding.

[a] Total includes “home pack” harvest.

Table 14.–Indexed foot survey peak salmon escapements by species at Telrod Creek (254-403), 1994–2009.

Year	Date	Sockeye [a]	Pink [a]
1994	ND	ND	ND
1995	15-Aug	120	233
1996	15-Sep	10	238
1997	11-Sep		350
	9-Oct	3,000	
1998	17-Aug	5,013	327
1999	31-Aug	1,220	
	10-Sep		60
2000	4-Sep	1,321	353
2001	18-Aug	1,600	450
2002	13-Aug		1,710
	17-Aug	1,880	
2003	14-Aug	5,252	450
2004	3-Aug	1,200	0
2005	11-Jul	500	100
2006 [b,c]	30-Jul	500	0
2007 [c]	29-Jul	300	0
2008 [c]	7-Jul	600	0
2009 [c]	31-Jul	25	0

[a] Survey estimates include salmon in stream mouth.

[b] The 30 July survey was an estimate of salmon in the plunge pool at the first waterfall barrier and does not represent a survey of the entire stream to the barrier.

[c] As specified in the renewed SUP, foot surveys of Telrod creek are no longer required.

Table 15.–Indexed aerial peak salmon escapements by species at Spiridon River (254-401), 1994–2009.

Year	Date	Observer	Survey Conditions	Survey counts [a] pink	chum	coho
1994	ND	ND	ND	ND	ND	ND
1995	17-Aug	ADF&G	good	87,800	22,000	
	13-Oct	FWS	good			10,300
1996	29-Aug	FWS	good	5,700	8,000	
	16-Oct	FWS	excellent			10,600
1997	1-Aug	ADF&G	good	18,100	5,500	
	9-Oct	ADF&G	excellent			13,300
1998	14-Aug	ADF&G	fair	29,500	6,150	
	14-Sep	FWS	good			1,750
1999	11-Aug	ADF&G	fair		15,000	
	27-Aug	ADF&G	fair	15,500		
2000	21-Aug	FWS	fair	1,000	16,500	
	20-Oct	FWS	good			2,900
2001	1-Aug	ADF&G	poor		3,000	
	7-Aug	ADF&G	fair	18,000		
	29-Oct	FWS	good			4,550
2002	2-Sep	ADF&G	fair to poor	32,000	6,500	
	3-Sep	ADF&G	poor		7,380	
					13,880 [b]	
2003	5-Aug	ADF&G	poor	5,000	5,700	
	5-Sep	ADF&G	poor			700
2004	ND	ND	ND	ND	ND	ND
2005 [c]	8-Aug	ADF&G	poor	5,000	6,400	0
	26-Aug	ADF&G	good to excellent	50	15,500	
2006	17-Aug	ADF&G	fair	14,700		
	26-Aug	ADF&G	fair		5,000	
2007	7-Aug	ADF&G	poor	10,000		
	6-Sep	ADF&G	fair	1,000	7,900	

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Table 15.–Page 2 of 2.

Year	Date	Observer	Survey Conditions	Survey counts [a] pink	chum	coho
2008	31-Jul	ADF&G	fair	9,400	200	0
	9-Aug	ADF&G	fair	32,000	11,400	0
2009 [d]	9-Aug	ADF&G	good	13,400	14,200	0
	19-Aug	ADF&G	good	6,300	4,300	0
	25-Aug	ADF&G	good	400	25,000	0

[a] Survey counts include stream, mouth, and bay areas.

[b] The 2002 peak chum estimate was a sum of the September 2 and 3 survey estimates. ADF&G manager's sum estimates were from surveys conducted on two consecutive days in determining the indexed peak count.

[c] The August 8 survey only included the upper river drainage.

[d] A survey count of 100 sockeye salmon carcasses were counted on 9-August.

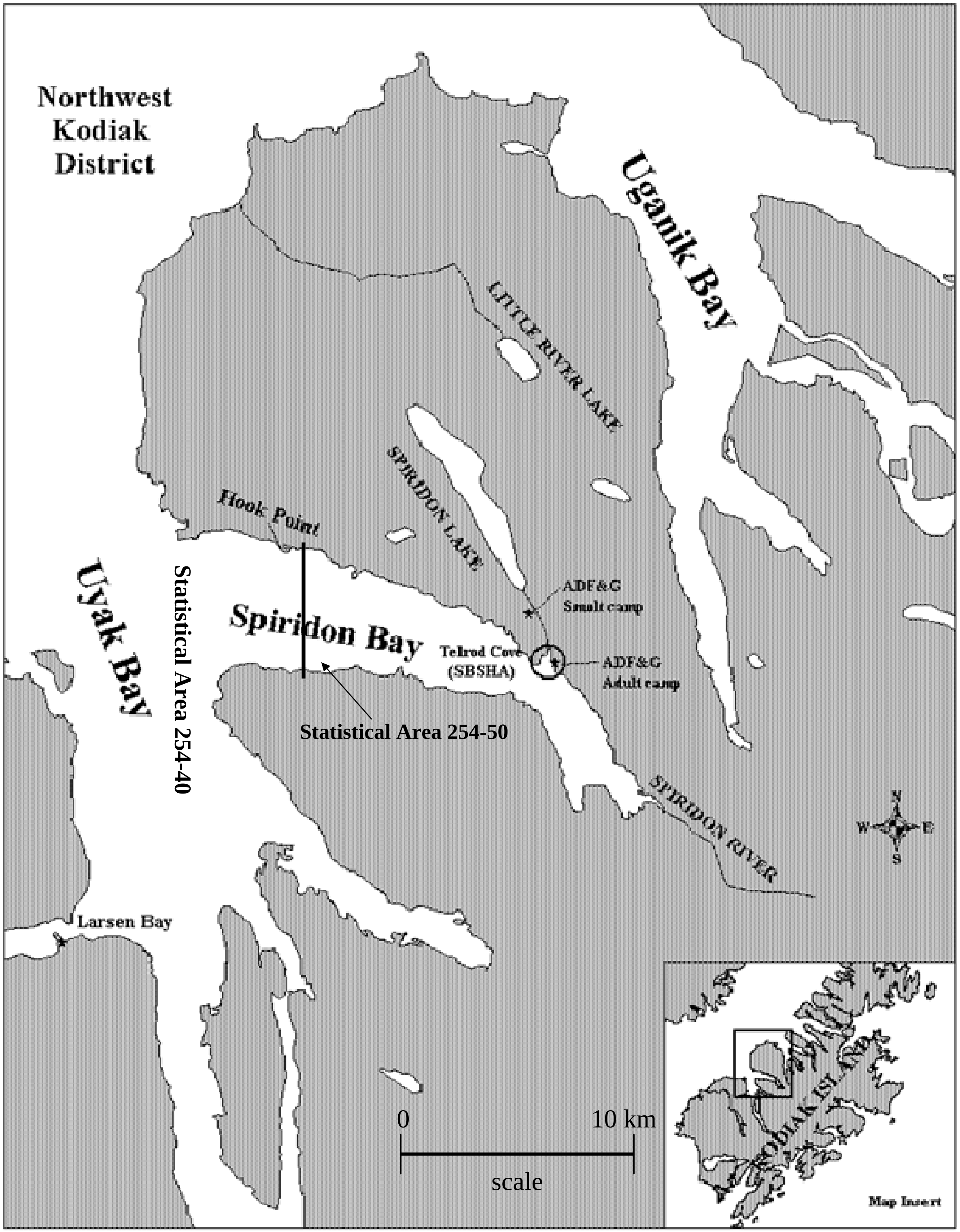

Figure 1.–Locations of ADF&G smolt and adult salmon field camps, Spiridon Lake, Telrod Cove, and Spiridon Bay in the Northwest Kodiak District.

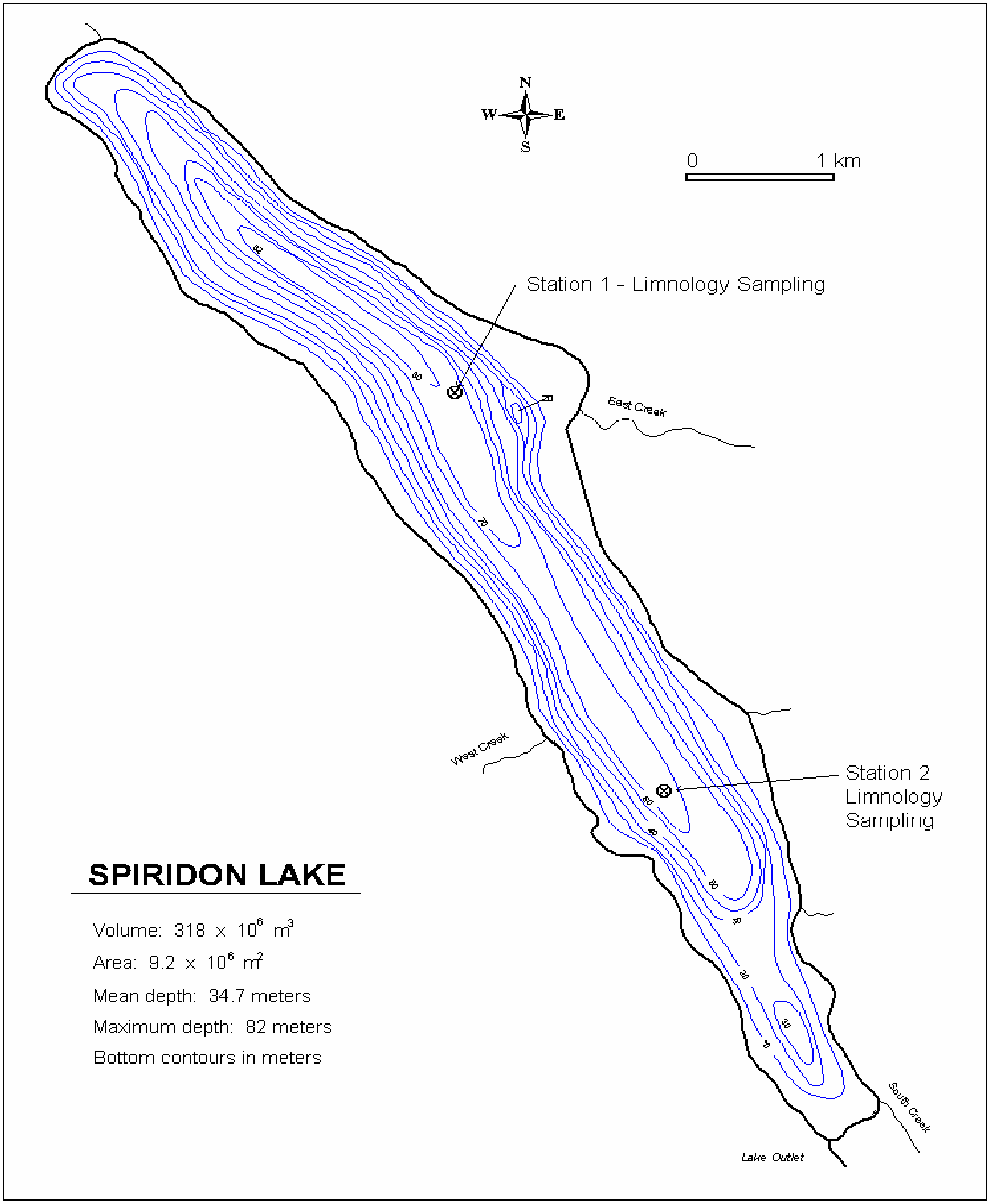

Figure 2.–Morphometric map showing the location of limnology sampling stations on Spiridon Lake.

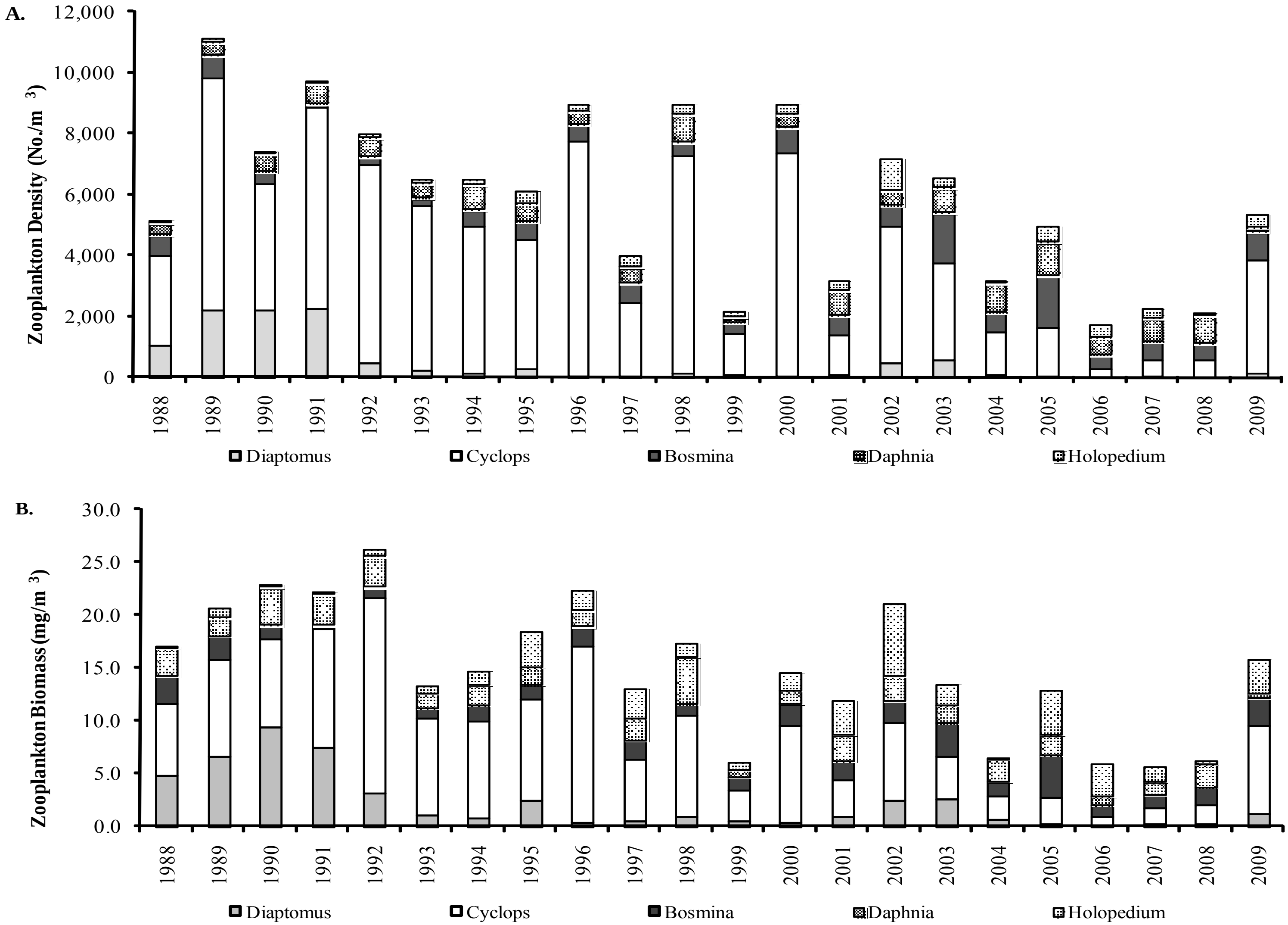

Figure 3.–Zooplankton density (A) and biomass (B) estimates for Spiridon Lake, 1988–2009.

APPENDIX A. HISTORICAL LIMNOLOGICAL DATA

Appendix A1.–Limnological sampling stations and samples collected for Spiridon Lake, 1988–2009.

Year	Sampling Stations	Total Samples
1988	1, 2	4
1989	1, 2	5
1990	1, 2	5
1991	1, 2	7
1992	1, 2	6
1993	1, 2	6
1994	1-4	6
1995	1-4	6
1996	1-4	6
1997	1-4	6
1998	1, 2	5
1999	1, 2	6
2000	1, 2	5
2001	1, 2	5
2002	1, 2	5
2003	1, 2	4
2004	1, 2, 5, 6	10
2005	1, 2, 5, 6	9
2006	1, 2, 5, 6	7
2007	1, 2	5
2008	1, 2	5
2009	1, 2	5

Note: Sampling stations 5 and 6 were placed in tributaries entering Spiridon Lake.

Appendix A2.–Summary of seasonal mean water chemistry parameters by station and depth for Spiridon Lake, 1988–2009.

		Depth	Sp. Cond.		pH		Alkalinity		Turbidity		Color		Calcium		Magnesium		Iron	
Year	Station	(m)	(µ mhos/cm)	SD	(Units)	SD	(µ g L)	SD	(NTU)	SD	(Pt units)	SD	(µ g L)	SD	(µ g L)	SD	(µ g L)	SD
1988	1	1	71.5	1.0	7.1	0.2	20.8	1.7	0.6	0.3	7.0	2.3	6.1	1.0	2.3	0.5	16.5	3.0
	1	50	71.5	0.6	7.0	0.1	20.5	1.3	0.6	0.4	5.8	0.5	6.1	0.8	2.2	0.7	12.0	3.3
	2	1	71.7	0.6	7.1	0.2	20.0	1.0	0.4	0.1	8.0	0.0	7.7	2.8	1.3	1.6	16.3	5.9
	2	50	71.6	0.5	7.0	0.1	19.4	0.9	0.7	0.5	7.4	2.8	5.4	0.2	3.2	1.0	15.0	6.7
1989	1	1	75.0	6.2	7.3	0.2	22.2	2.8	0.3	0.1	13.8	6.4	5.7	1.0	2.0	0.3	8.6	3.6
	1	50	76.8	8.6	7.3	0.2	22.8	3.5	0.3	0.1	12.4	3.8	6.3	0.6	2.3	0.7	12.0	9.0
	2	1	73.6	1.5	7.3	0.2	21.4	0.9	0.7	0.6	12.0	3.9	5.9	0.4	2.4	0.4	25.2	35.4
	2	50	72.6	1.7	7.3	0.1	20.2	4.1	0.8	0.9	14.4	6.2	5.8	0.6	2.4	0.7	84.4	144.4
1990	1	1	76.2	7.2	7.4	0.2	23.7	2.6	0.5	0.4	5.0	1.9	5.7	0.9	2.2	0.6	14.0	8.8
	1	50	73.2	1.9	7.3	0.2	23.4	1.5	0.5	0.4	4.8	0.8	6.1	0.6	2.3	0.6	16.4	8.3
	2	1	73.0	1.2	7.4	0.1	23.2	1.3	0.5	0.3	6.0	2.8	6.3	0.5	2.0	0.5	19.4	7.3
	2	50	73.2	0.8	7.3	0.2	23.0	1.6	0.5	0.4	5.8	2.9	5.7	0.8	2.5	0.6	15.8	12.0
1991	1	1	83.7	23.5	7.3	0.1	21.1	3.6	0.7	0.4	6.6	2.2	6.1	0.4	2.4	0.8	23.0	23.9
	1	50	75.4	4.0	7.3	0.1	22.1	2.0	1.5	2.1	7.4	3.9	6.2	0.7	2.4	0.5	113.9	232.1
	2	1	74.3	4.4	7.4	0.1	23.0	0.6	0.7	0.5	8.4	5.9	6.4	0.4	2.3	0.3	22.4	13.8
	2	50	75.0	1.7	7.3	0.2	25.9	8.0	0.8	0.4	6.1	4.1	6.1	0.6	2.2	0.4	29.4	25.3
1992	1	1	72.8	1.3	7.1	0.1	20.4	0.8	0.7	0.3	4.2	0.4	5.9	0.7	2.5	0.8	20.5	9.2
	1	50	74.3	0.5	7.1	0.1	20.8	0.4	0.5	0.1	8.0	4.8	6.2	0.5	2.3	0.5	19.7	9.3
	2	1	74.2	0.8	7.2	0.1	21.0	0.0	0.6	0.3	8.2	4.3	6.2	0.7	2.5	1.0	18.2	7.6
	2	50	73.8	0.4	7.0	0.1	20.7	0.4	0.7	0.5	4.2	2.5	6.0	0.9	2.2	0.4	14.6	4.4
1993	1	1	80.3	5.2	7.3	0.6	23.1	2.5	1.1	1.3	3.5	0.8	6.7	1.6	2.2	0.6	15.8	9.7
	1	50	89.2	28.0	7.0	0.4	22.3	2.3	1.0	0.6	3.5	0.8	6.2	0.7	2.8	1.0	23.0	15.1
	2	1	79.8	5.6	7.3	0.6	23.6	2.8	0.8	0.6	4.8	2.4	6.5	1.2	2.5	0.4	15.0	7.6
	2	50	78.3	2.4	7.0	0.1	21.8	0.8	0.4	0.1	4.5	2.1	6.1	0.6	2.5	0.4	13.7	7.3

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Appendix A2.–Page 2 of 6.

		Depth	Sp. Cond.		pH		Alkalinity		Turbidity		Color		Calcium		Magnesium		Iron	
Year	Station	(m)	(µ mhos/cm)	SD	(Units)	SD	(µ g L)	SD	(NTU)	SD	(Pt units)	SD	(µ g L)	SD	(µ g L)	SD	(µ g L)	SD
1994	1	1	77.3	0.8	6.9	0.4	21.8	1.3	0.4	0.1	8.5	1.5	6.3	0.5	2.2	0.3	7.7	9.1
	1	50	78.7	2.3	6.9	0.3	21.9	0.9	0.3	0.1	8.0	1.5	6.3	0.5	2.4	0.7	5.3	4.4
	2	1	77.3	1.0	7.0	0.3	22.1	0.8	0.4	0.1	9.2	2.3	6.1	0.4	2.5	0.7	18.2	25.2
	2	50	77.7	0.8	6.9	0.3	22.3	0.9	0.7	0.9	7.8	3.3	6.1	0.4	2.3	0.3	31.2	48.1
1995	1	1	76.0	3.1	6.8	0.1	21.7	0.5	1.0	0.7	4.2	1.5	5.6	0.2	2.4	0.3	10.8	4.6
	1	50	75.4	1.5	6.9	0.1	22.5	2.0	0.7	0.5	5.5	2.3	5.8	0.5	2.8	0.8	9.0	6.0
	2	1	76.3	2.8	7.0	0.1	22.3	0.7	0.7	0.6	3.7	1.2	5.8	0.3	2.3	0.5	11.3	6.3
	2	50	76.0	2.0	6.9	0.2	22.8	1.2	0.7	0.6	6.3	4.6	5.8	0.3	2.3	0.5	11.3	5.4
1996	1	1	77.0	2.8	7.0	0.2	22.4	0.6	0.6	0.2	4.2	0.8	5.5	0.1	2.6	0.2	10.7	4.5
	1	50	77.3	3.0	7.0	0.1	22.6	1.1	0.6	0.3	4.8	1.8	5.5	0.1	2.6	0.2	8.8	4.0
	2	1	76.8	1.5	7.2	0.1	22.0	0.4	0.6	0.4	4.0	0.6	5.5	0.1	2.6	0.2	13.5	9.6
	2	50	77.7	2.4	7.0	0.1	22.0	0.5	0.6	0.2	5.8	3.5	5.5	0.1	2.6	0.2	7.7	1.4
1997	1	1	75.7	3.3	7.6	0.3	24.8	2.6	0.5	0.1	7.8	5.6	5.8	0.9	2.5	0.4	13.8	3.9
	1	2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	1	50	75.2	0.4	7.4	0.1	23.6	0.6	0.5	0.1	5.7	1.4	5.4	0.2	2.4	0.5	11.5	5.3
	2	1	75.3	0.5	7.5	0.0	24.1	1.0	0.5	0.1	5.3	2.2	5.5	0.2	2.5	0.4	12.5	5.5
	2	2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	2	50	75.0	0.6	7.4	0.1	23.7	0.6	0.4	0.1	7.5	2.1	5.4	0.3	2.7	0.4	10.8	5.0
1998	1	1	72.3	0.5	7.4	0.1	24.5	2.0	1.0	0.4	7.5	3.4	5.8	0.2	2.4	0.1	11.5	5.7
	1	50	73.8	0.5	7.3	0.1	22.9	0.7	0.7	0.4	5.5	0.6	5.7	0.1	2.5	0.0	9.3	4.6
	2	1	74.0	0.8	7.4	0.1	24.6	1.9	1.0	0.7	5.8	2.9	5.7	0.1	2.5	0.1	10.8	5.9
	2	50	72.0	3.4	7.3	0.0	23.7	1.5	0.6	0.4	5.0	0.8	5.7	0.1	2.5	0.1	9.3	5.3
1999	1	1	70.3	1.7	7.2	0.3	22.3	0.7	0.4	0.1	4.0	0.8	5.7	0.1	2.6	0.1	28.3	16.0
	1	50	71.5	1.7	7.2	0.2	22.4	0.5	0.6	0.5	3.5	1.3	5.9	0.1	2.4	0.0	29.0	16.8
	2	1	71.2	1.3	7.1	0.2	22.4	0.8	0.6	0.4	4.2	0.8	5.7	0.1	2.5	0.2	25.8	15.3
	2	50	72.0	0.7	7.1	0.2	22.1	0.4	0.6	0.4	3.2	0.4	5.7	0.1	2.5	0.1	24.4	10.6

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Appendix A2.–Page 3 of 6.

Year	Station	Depth (m)	Sp. Cond. (μ mhos/cm)	SD	pH (Units)	SD	Alkalinity (μ g L)	SD	Turbidity (NTU)	SD	Color (Pt units)	SD	Calcium (μ g L)	SD	Magnesium (μ g L)	SD	Iron (μ g L)	SD
2000	1	1	ND	ND	7.6	0.2	13.3	1.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	2	1	ND	ND	7.6	0.2	13.7	1.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2001	1	1	ND	ND	7.5	0.4	19.3	4.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	2	1	ND	ND	7.5	0.4	19.4	3.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2002	1	1	ND	ND	7.4	0.0	21.5	0.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	2	1	ND	ND	7.4	0.0	21.6	0.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2003	1	1	ND	ND	7.4	0.1	21.6	0.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	2	1	ND	ND	7.3	0.0	21.6	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2004	1	1	76.5	0.0	7.2	0.2	21.7	0.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	1	5	ND	ND	7.2	0.2	21.5	0.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	1	10	ND	ND	7.2	0.2	21.4	0.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	1	15	ND	ND	7.2	0.2	21.5	0.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	1	20	ND	ND	7.1	0.2	21.1	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	1	25	ND	ND	7.2	0.1	21.0	0.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	1	30	ND	ND	7.2	0.2	20.9	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	1	35	ND	ND	7.2	0.2	21.1	0.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	1	50	ND	ND	7.1	0.1	21.0	0.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	2	1	ND	ND	7.2	0.1	21.3	0.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	2	5	ND	ND	7.2	0.1	21.6	0.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	2	10	ND	ND	7.2	0.1	21.5	1.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	2	15	ND	ND	7.2	0.1	20.9	0.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	2	20	ND	ND	7.2	0.2	21.1	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	2	25	ND	ND	7.2	0.1	21.0	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	2	30	ND	ND	7.2	0.1	21.0	0.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	2	35	ND	ND	7.2	0.2	20.7	0.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	2	50	ND	ND	7.1	0.1	21.3	0.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	5	1	68.2	0.0	7.1	0.2	30.6	12.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	6	1	ND	ND	7.1	0.2	21.8	3.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

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Appendix A2.–Page 4 of 6.

Year	Station	Depth (m)	Sp. Cond. (μ mhos/cm)	SD	pH (Units)	SD	Alkalinity (μ g L)	SD	Turbidity (NTU)	SD	Color (Pt units)	SD	Calcium (μ g L)	SD	Magnesium (μ g L)	SD	Iron (μ g L)	SD
2005	1	1	ND	ND	7.1	0.1	21.4	0.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	1	5	ND	ND	7.1	0.1	21.1	0.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	1	10	ND	ND	7.1	0.1	21.2	0.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	1	15	ND	ND	7.1	0.1	21.0	0.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	1	20	ND	ND	7.1	0.1	21.1	0.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	1	25	ND	ND	7.1	0.1	20.8	0.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	1	30	ND	ND	7.1	0.1	20.7	0.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	1	35	ND	ND	7.1	0.1	20.7	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	1	50	ND	ND	7.1	0.1	20.7	0.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	2	1	ND	ND	7.1	0.1	21.4	0.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	2	5	ND	ND	7.1	0.1	21.4	0.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	2	10	ND	ND	7.1	0.1	21.3	0.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	2	15	ND	ND	7.1	0.1	21.4	0.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	2	20	ND	ND	7.1	0.1	21.0	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	2	25	ND	ND	7.1	0.1	20.8	0.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	2	30	ND	ND	7.1	0.1	21.0	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	2	35	ND	ND	7.1	0.1	20.9	0.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	2	50	ND	ND	7.1	0.1	20.7	0.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	5	1	ND	ND	7.1	0.1	31.6	9.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	6	1	ND	ND	7.1	0.1	23.1	5.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

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Appendix A2.–Page 5 of 6.

		Depth	Sp. Cond.		pH		Alkalinity		Turbidity		Color		Calcium		Magnesium		Iron	
Year	Station	(m)	(μ mhos/cm)	SD	(Units)	SD	(μ g L)	SD	(NTU)	SD	(Pt units)	SD	(μ g L)	SD	(μ g L)	SD	(μ g L)	SD
2006	1	1	ND	ND	7.3	0.1	21.9	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	1	5	ND	ND	7.3	0.1	21.3	0.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	1	10	ND	ND	7.3	0.1	21.5	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	1	15	ND	ND	7.3	0.1	21.5	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	1	20	ND	ND	7.3	0.1	21.3	0.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	1	25	ND	ND	7.3	0.1	21.3	0.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	1	30	ND	ND	7.3	0.1	21.2	0.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	1	35	ND	ND	7.3	0.1	21.3	0.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	1	50	ND	ND	7.3	0.1	21.3	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	2	1	ND	ND	7.3	0.1	21.6	0.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	2	5	ND	ND	7.3	0.1	21.8	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	2	10	ND	ND	7.3	0.1	21.3	0.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	2	15	ND	ND	7.3	0.1	21.3	0.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	2	20	ND	ND	7.3	0.1	21.2	0.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	2	25	ND	ND	7.3	0.1	21.3	0.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	2	30	ND	ND	7.3	0.1	21.3	0.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	2	35	ND	ND	7.3	0.1	21.1	0.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	2	50	ND	ND	7.3	0.1	21.1	0.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	5	1	ND	ND	7.2	0.1	28.7	5.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	6	1	ND	ND	7.3	0.1	19.8	2.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

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Appendix A2.–Page 6 of 6.

		Depth	Sp. Cond.		pH		Alkalinity		Turbidity		Color		Calcium		Magnesium		Iron	
Year	Station	(m)	(µ mhos/cm)	SD	(Units)	SD	(µ g L)	SD	(NTU)	SD	(Pt units)	SD	(µ g L)	SD	(µ g L)	SD	(µ g L)	SD
2007	1	1	ND	ND	7.3	0.0	22.7	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	1	50	ND	ND	7.4	0.0	22.7	0.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	2	1	ND	ND	7.4	0.0	22.5	0.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	2	50	ND	ND	7.4	0.0	22.2	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2008	1	1	ND	ND	7.2	0.1	21.9	0.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	1	50	ND	ND	7.2	0.0	21.6	0.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	2	1	ND	ND	7.2	0.1	21.8	0.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	2	50	ND	ND	7.2	0.1	21.4	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2009	1	1	ND	ND	7.4	0.2	22.0	0.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	1	50	ND	ND	7.4	0.2	12.6	0.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	2	1	ND	ND	7.5	0.2	21.0	1.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	2	50	ND	ND	7.5	0.2	20.9	2.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Appendix A3.– Summary of seasonal mean nutrient and algal pigment concentrations by station and depth for Spiridon Lake, 1988–2009.

Year	Station	Depth (m)	Total - P (μ g L)	SD	Total filter-able - P (μ g L)	SD	Filterable reactive - P (μ g L)	SD	Total Kjel-dahl - N (μ g L)	SD	Ammonia (μ g L)	SD	Nitrate + nitrite (μ g L)	SD	Reactive silicon (μ g L)	SD	Chlorophyll *a* (μ g L)	SD
1988	1	1	3.8	1.4	3.0	1.1	2.5	1.2	102.8	11.4	9.9	2.7	220.5	26.0	2,171	160	0.45	0.1
	1	50	3.8	0.6	2.2	0.6	1.7	0.5	94.9	9.0	11.2	5.5	256.9	9.6	2,279	172	0.16	0.1
	2	1	3.5	0.1	2.0	0.6	1.8	0.3	100.5	11.3	7.8	6.6	221.3	11.1	2,283	170	0.40	0.1
	2	50	4.0	0.6	1.9	0.6	1.8	0.5	91.4	9.9	8.6	4.4	236.2	27.5	2,237	157	0.29	0.1
1989	1	1	3.6	0.7	3.7	1.9	3.0	2.2	103.4	7.6	8.5	2.5	207.1	35.4	2,162	214	0.19	0.1
	1	50	4.2	1.0	3.2	1.2	2.4	0.4	97.9	18.6	11.5	7.3	242.8	54.9	2,277	353	0.32	0.2
	2	1	6.1	3.7	2.7	1.0	2.5	0.4	114.8	45.7	9.5	5.2	197.9	61.9	2,129	119	0.18	0.1
	2	50	7.3	7.8	2.7	0.7	2.7	0.7	104.0	40.1	12.5	11.0	209.8	50.4	2,173	109	0.37	0.3
1990	1	1	3.5	1.8	2.4	0.6	2.0	0.8	92.5	16.5	4.9	2.0	203.4	36.8	2,114	93	0.23	0.1
	1	50	3.0	0.7	2.8	0.5	2.0	0.6	85.3	10.9	6.3	2.5	228.5	24.8	2,171	96	0.34	0.2
	2	1	2.4	0.6	4.1	3.2	3.3	2.4	83.2	6.4	4.7	1.7	185.0	79.4	2,127	80	0.24	0.1
	2	50	2.5	0.8	2.8	1.1	2.9	1.9	87.7	12.3	6.6	2.8	187.3	80.1	2,205	109	0.24	0.1
1991	1	1	4.9	5.9	2.8	0.8	2.6	0.9	93.7	7.3	7.6	4.4	234.0	38.1	2,082	57	0.38	0.1
	1	50	5.2	3.7	3.3	2.0	2.8	1.4	87.5	12.9	9.4	4.8	265.1	20.9	2,131	54	0.20	0.1
	2	1	3.6	0.8	4.8	3.3	4.6	3.3	91.8	8.6	8.2	4.5	237.0	29.6	2,081	66	0.35	0.1
	2	50	3.8	1.5	3.6	3.3	3.4	3.2	88.6	7.4	11.3	5.8	267.7	7.7	2,137	46	0.25	0.1
1992	1	1	3.7	0.6	2.1	0.7	1.5	0.5	89.6	10.1	1.5	0.8	239.5	12.3	2,082	131	0.27	0.1
	1	50	4.9	1.4	4.2	3.1	3.7	3.0	87.0	8.0	4.6	3.3	258.7	16.9	2,111	102	0.22	0.1
	2	1	3.6	0.3	2.6	1.4	2.4	1.4	98.4	18.2	1.7	0.6	235.2	25.9	2,025	90	0.27	0.2
	2	50	4.5	0.8	3.1	2.8	2.0	1.1	83.2	24.8	5.3	3.7	273.4	7.7	2,112	46	0.23	0.1
1993	1	1	2.7	0.9	2.2	1.1	1.6	0.8	93.6	11.2	2.4	1.5	231.6	37.6	2,023	164	0.75	0.2
	1	50	3.0	0.9	3.0	4.0	1.8	1.8	90.7	10.8	5.2	3.4	240.2	22.8	2,122	94	0.42	0.2
	2	1	2.9	1.0	3.2	3.5	2.6	3.3	97.0	12.0	1.8	0.5	230.3	41.5	2,026	163	0.77	0.3
	2	50	2.5	0.1	3.2	2.5	2.8	2.5	85.4	3.8	5.4	3.7	247.7	30.6	2,128	96	0.40	0.2

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Appendix A3.–Page 2 of 6.

Year	Station	Depth (m)	Total - P (µ g L)	SD	Total filter-able - P (µ g L)	SD	Filterable reactive - P (µ g L)	SD	Total Kjel-dahl - N (µ g L)	SD	Ammonia (µ g L)	SD	Nitrate + nitrite (µ g L)	SD	Reactive silicon (µ g L)	SD	Chlorophyll *a* (µ g L)	SD
1994	1	1	3.2	1.3	1.9	1.5	1.5	1.1	101.8	3.9	3.2	4.7	204.3	22.1	2,092	131	0.26	0.2
	1	50	3.9	2.0	1.2	0.2	1.1	0.4	97.5	16.1	6.7	3.6	218.1	18.3	2,184	95	0.21	0.1
	2	1	2.8	0.7	2.2	1.5	1.4	0.9	105.7	12.8	1.6	1.3	202.1	17.2	2,144	77	0.31	0.1
	2	50	3.3	1.2	2.2	1.3	1.9	1.1	105.6	13.2	5.8	2.5	225.7	20.6	2,190	85	0.20	0.1
1995	1	1	3.4	2.2	0.9	0.1	0.9	0.2	108.8	12.3	2.2	1.6	203.1	26.8	2300	95	0.95	0.5
	1	50	3.4	1.3	1.5	0.3	1.4	0.4	105.6	20.4	3.5	2.4	241.6	6.6	2340	105	0.58	0.4
	2	1	3.9	2.0	1.2	0.4	1.1	0.2	125.2	24.1	2.2	1.0	213.4	19.8	2297	75	1.02	0.4
	2	50	3.2	0.9	0.9	0.2	0.9	0.1	108.2	18.6	4.5	3.0	243.1	9.1	2329	102	0.58	0.5
1996	1	1	2.7	0.6	1.5	0.9	1.0	0.5	113.4	34.1	5.1	2.8	183.6	18.5	2042	93	0.49	0.2
	1	50	3.0	1.1	1.3	0.7	1.0	0.4	90.5	18.5	9.3	5.0	210.8	9.0	2148	51	0.51	0.2
	2	1	2.7	0.7	1.4	0.7	1.1	0.3	105.5	20.7	5.6	1.6	180.2	14.4	2083	82	0.47	0.1
	2	50	4.4	1.7	1.5	0.7	1.5	1.3	101.1	16.9	10.2	4.1	217.9	2.4	2179	82	0.57	0.3
1997	1	1	3.0	0.6	3.4	3.5	3.5	4.1	103.6	12.0	11.2	5.8	147.4	31.1	2155	64	0.57	0.3
	1	2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.58	0.4
	1	50	2.8	0.7	1.8	0.4	1.8	0.5	90.5	5.2	11.1	6.3	191.0	19.7	2223	98	0.38	0.2
	2	1	3.1	0.9	3.2	3.3	3.1	3.2	106.1	11.3	11.2	6.4	168.2	25.2	2139	103	0.59	0.3
	2	2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.57	0.3
	2	50	3.8	1.5	3.1	1.0	3.2	1.0	107.4	30.3	10.7	6.2	188.3	17.5	2205	83	0.44	0.2
1998	1	1	4.8	1.6	2.7	1.8	1.7	1.0	138.3	20.5	8.4	6.1	121.5	24.7	2239	174	0.43	0.3
	1	50	4.0	0.4	1.6	0.8	1.3	0.5	118.4	10.1	10.2	5.4	174.4	19.6	2355	42	0.14	0.0
	2	1	3.9	1.2	1.5	1.1	1.4	0.6	124.6	10.1	4.9	1.4	148.3	12.2	2262	105	0.38	0.3
	2	50	4.0	1.7	1.5	0.9	1.5	0.7	122.9	12.0	9.6	4.5	171.9	26.4	2297	93	0.21	0.1
1999	1	1	4.0	2.5	1.9	0.5	1.5	0.5	93.0	4.8	6.4	2.9	188.0	33.8	2432	141	0.49	0.3
	1	50	3.2	0.4	1.7	0.7	1.2	0.5	92.0	2.7	6.9	3.8	211.4	6.1	2478	208	0.15	0.0
	2	1	2.7	0.3	2.3	0.7	1.7	0.4	103.5	14.3	6.2	4.1	193.4	24.0	2465	152	0.30	0.2
	2	50	3.0	0.6	2.3	1.6	1.7	1.4	87.9	15.3	11.2	6.0	208.1	10.1	2525	157	0.25	0.1

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Appendix A3.–Page 3 of 6.

Year	Station	Depth (m)	Total - P (μg L)	SD	Total filterable - P (μg L)	SD	Filterable reactive - P (μg L)	SD	Total Kjeldahl - N (μg L)	SD	Ammonia (μg L)	SD	Nitrate + nitrite (μg L)	SD	Reactive silicon (μg L)	SD	Chlorophyll *a* (μg L)	SD
2000	1	1	7.0	4.5	3.4	3.8	2.3	2.2	ND	ND	8.7	8.6	195.5	1.8	ND	ND	0.58	0.1
	2	1	6.1	8.7	3.3	4.6	2.0	2.0	ND	ND	7.5	8.0	184.0	15.7	ND	ND	0.77	0.2
2001	1	1	4.9	3.3	3.5	2.1	1.9	2.0	101.2	8.0	4.6	4.7	193.8	6.7	ND	ND	0.60	0.3
	2	1	6.7	5.1	3.5	3.3	2.7	3.5	ND	ND	2.1	1.3	189.2	7.3	ND	ND	0.60	0.1
2002	1	1	3.3	2.6	1.5	0.9	3.0	1.9	96.7	14.5	5.0	2.3	136.5	7.9	ND	ND	0.32	0.0
	2	1	4.0	1.9	1.3	1.3	1.9	1.0	ND	ND	3.4	1.7	135.0	21.2	ND	ND	0.45	0.2
2003	1	1	5.7	0.8	2.8	3.4	2.6	1.7	100.3	10.1	2.6	2.1	203.3	36.7	ND	ND	0.70	0.4
	2	1	3.5	0.7	1.4	1.1	3.6	0.8	ND	ND	1.9	2.0	201.3	22.1	ND	ND	0.60	0.3
2004	1	1	4.4	2.9	0.9	0.9	1.5	1.1	98.7	47.6	6.8	2.1	197.3	19.1	2165	217	0.60	0.2
	1	5	3.6	1.8	ND	ND	0.8	1.3	ND	ND	4.9	1.0	160.2	19.2	2214	146	0.48	0.2
	1	10	4.6	1.7	ND	ND	1.0	1.5	ND	ND	5.8	2.2	162.0	18.1	2207	111	0.54	0.2
	1	15	11.6	20.9	ND	ND	1.2	1.8	ND	ND	5.3	1.8	168.6	17.8	2215	108	0.54	0.3
	1	20	3.9	2.2	ND	ND	1.0	1.5	ND	ND	5.6	2.1	173.0	14.6	2242	110	0.63	0.3
	1	25	3.6	1.7	ND	ND	1.5	2.6	ND	ND	6.7	2.3	179.0	11.1	2277	114	0.48	0.2
	1	30	6.2	5.0	ND	ND	0.6	1.0	ND	ND	7.5	2.3	174.1	22.4	2298	115	0.59	0.3
	1	35	6.3	4.5	ND	ND	0.7	1.1	ND	ND	8.3	3.0	182.3	11.8	2377	195	0.56	0.4
	1	50	4.8	5.1	ND	ND	0.7	1.1	ND	ND	7.7	3.0	199.7	11.5	2365	144	0.61	0.2
	2	1	4.6	4.4	2.0	3.9	2.0	0.9	109.9	73.1	7.2	1.3	186.4	19.6	2223	183	0.82	0.7
	2	5	5.5	3.7	ND	ND	1.8	0.7	ND	ND	5.8	1.9	168.6	30.1	2201	171	0.51	0.2
	2	10	6.6	4.8	ND	ND	2.1	1.3	ND	ND	4.3	0.6	161.0	19.8	2205	166	0.46	0.2
	2	15	7.4	5.1	ND	ND	2.0	1.2	ND	ND	5.1	0.2	170.6	14.2	2237	189	0.56	0.3
	2	20	7.6	4.3	ND	ND	1.6	1.2	ND	ND	4.7	0.5	176.7	11.6	2265	174	0.46	0.2
	2	25	6.8	3.8	ND	ND	1.9	1.4	ND	ND	4.3	0.5	180.8	10.9	2332	213	0.46	0.4
	2	30	5.0	2.2	ND	ND	1.9	0.9	ND	ND	4.6	0.0	173.7	18.7	2327	199	0.49	0.3
	2	35	7.8	3.9	ND	ND	2.9	3.5	ND	ND	5.2	1.0	187.6	8.7	2416	226	0.52	0.4
	2	50	10.0	7.3	ND	ND	2.3	1.9	ND	ND	7.9	3.3	200.3	12.0	2402	222	0.49	0.2
	5	1	8.2	3.7	ND	ND	3.8	1.2	ND	ND	11.5	6.6	71.9	135.4	4504	1063	0.30	0.2
	6	1	15.7	7.6	ND	ND	2.8	2.6	ND	ND	8.1	4.8	42.8	64.1	1897	1079	1.08	0.5

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Year	Station	Depth (m)	Total - P (μ g L)	SD	Total filter-able - P (μ g L)	SD	Filterable reactive - P (μ g L)	SD	Total Kjel-dahl - N (μ g L)	SD	Ammonia (μ g L)	SD	Nitrate + nitrite (μ g L)	SD	Reactive silicon (μ g L)	SD	Chlorophyll *a* (μ g L)	SD
2005	1	1	2.7	1.2	1.8	1.5	0.5	1.2	147.4	135.4	4.7	1.6	139.5	28.2	2083	315	0.51	0.2
	1	5	2.5	1.4	ND	ND	0.4	1.0	ND	ND	6.4	1.8	140.1	27.8	2169	158	0.50	0.2
	1	10	2.9	1.3	ND	ND	0.1	0.3	ND	ND	6.3	1.6	139.9	25.5	2170	163	0.47	0.2
	1	15	2.3	0.9	ND	ND	0.1	0.2	ND	ND	6.3	1.7	146.6	23.9	2171	167	0.63	0.2
	1	20	2.4	1.6	ND	ND	0.2	0.4	ND	ND	10.9	9.7	142.3	23.9	2181	170	0.58	0.1
	1	25	2.4	1.1	ND	ND	0.1	0.3	ND	ND	7.1	1.5	154.4	14.4	2212	136	0.53	0.1
	1	30	1.9	1.0	ND	ND	0.1	0.2	ND	ND	7.8	2.6	156.6	15.1	2228	142	0.40	0.1
	1	35	2.2	1.1	ND	ND	0.1	0.3	ND	ND	9.2	2.7	160.6	12.2	2242	120	0.36	0.2
	1	50	3.9	1.2	ND	ND	0.2	0.4	40.1	31.4	10.0	2.5	163.7	11.9	2263	115	0.26	0.2
	2	1	4.1	0.7	1.0	0.9	0.5	0.7	152.6	62.0	4.9	2.0	142.5	15.6	2147	154	0.52	0.2
	2	5	ND	ND	ND	ND	0.3	0.6	ND	ND	4.7	2.3	142.7	16.2	2146	170	0.51	0.2
	2	10	ND	ND	ND	ND	0.3	0.4	ND	ND	4.9	2.1	143.7	17.2	2156	171	0.56	0.3
	2	15	ND	ND	ND	ND	0.3	0.7	ND	ND	5.3	2.3	152.0	18.1	2181	167	0.64	0.4
	2	20	ND	ND	ND	ND	0.5	0.8	ND	ND	6.0	1.9	163.1	21.8	2260	90	0.53	0.2
	2	25	ND	ND	ND	ND	0.7	1.1	ND	ND	6.7	1.9	164.6	23.4	2228	138	0.49	0.3
	2	30	ND	ND	ND	ND	0.4	0.6	ND	ND	6.8	2.9	167.0	24.1	2247	137	0.33	0.2
	2	35	ND	ND	ND	ND	0.7	0.8	ND	ND	6.9	3.1	159.7	28.6	2237	130	0.32	0.2
	2	50	5.1	2.1	ND	ND	0.3	0.6	139.8	44.7	7.6	2.7	169.7	24.4	2256	120	0.29	0.2
	5	1	8.2	3.1	ND	ND	0.1	0.2	ND	ND	6.6	1.2	38.1	56.3	3755	562	0.49	0.4
	6	1	9.3	3.3	ND	ND	0.2	0.3	ND	ND	8.5	4.4	70.4	100.2	1761	1144	1.11	0.4

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Appendix A3.–Page 5 of 6.

Year	Station	Depth (m)	Total - P (μ g L)	SD	Total filter-able - P (μ g L)	SD	Filterable reactive - P (μ g L)	SD	Total Kjel-dahl - N (μ g L)	SD	Ammonia (μ g L)	SD	Nitrate + nitrite (μ g L)	SD	Reactive silicon (μ g L)	SD	Chlorophyll *a* (μ g L)	SD
2006	1	1	1.4	1.3	1.7	0.2	1.0	0.5	255.9	166.5	7.0	1.4	182.7	15.3	2497	149	0.68	0.2
	1	5	0.3	ND	ND	ND	1.0	0.9	ND	ND	3.4	1.4	148.2	24.0	2542	126	0.82	0.2
	1	10	2.3	0.8	ND	ND	1.1	0.8	ND	ND	3.2	1.4	152.2	12.1	2499	234	0.78	0.4
	1	15	ND	ND	ND	ND	1.0	0.7	ND	ND	3.6	1.2	158.3	12.7	2575	150	0.90	0.5
	1	20	1.8	1.5	ND	ND	0.9	0.8	ND	ND	5.0	2.0	163.9	9.5	2592	102	0.82	0.4
	1	25	0.3	ND	ND	ND	0.8	0.7	ND	ND	6.2	2.0	167.3	9.8	2591	123	0.86	0.4
	1	30	ND	ND	ND	ND	0.6	0.6	ND	ND	6.8	2.6	163.1	19.0	2543	232	0.77	0.4
	1	35	ND	ND	ND	ND	0.6	0.6	ND	ND	7.2	2.3	151.8	39.2	2544	230	0.71	0.4
	1	50	1.5	1.5	ND	ND	0.4	0.5	183.1	148.7	12.2	2.0	190.4	10.0	2652	198	0.53	0.2
	2	1	1.7	1.3	1.5	0.2	0.9	0.4	ND	ND	7.2	1.5	181.8	17.2	2523	183	0.74	0.2
	2	5	ND	ND	ND	ND	0.5	0.6	ND	ND	3.4	1.2	149.5	23.3	2559	263	0.86	0.3
	2	10	ND	ND	ND	ND	0.5	0.5	ND	ND	4.3	3.1	157.0	12.8	2656	185	0.87	0.3
	2	15	ND	ND	ND	ND	0.6	0.7	ND	ND	5.7	5.3	152.5	17.7	2525	256	0.86	0.3
	2	20	ND	ND	ND	ND	1.1	1.9	ND	ND	7.5	7.1	160.0	8.4	2553	201	0.88	0.4
	2	25	ND	ND	ND	ND	0.5	0.4	ND	ND	6.4	2.6	169.3	7.2	2593	214	0.82	0.5
	2	30	ND	ND	ND	ND	0.4	0.3	ND	ND	7.5	3.3	170.4	11.0	2615	206	0.71	0.4
	2	35	ND	ND	ND	ND	0.5	0.5	ND	ND	7.4	3.9	171.5	9.1	2629	274	0.56	0.3
	2	50	2.4	3.0	ND	ND	0.4	0.4	ND	ND	13.4	2.0	197.5	12.5	2662	193	0.61	0.4
	5	1	4.0	1.7	ND	ND	1.0	0.8	ND	ND	4.7	1.7	52.5	92.5	4433	544	0.56	0.3
	6	1	8.1	0.8	ND	ND	0.6	0.6	ND	ND	7.1	2.2	32.1	45.1	3050	866	1.12	0.3

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Appendix A3.–Page 6 of 6.

Year	Station	Depth (m)	Total - P (μ g L)	SD	Total filter-able - P (μ g L)	SD	Filterable reactive - P (μ g L)	SD	Total Kjel-dahl - N (μ g L)	SD	Ammonia (μ g L)	SD	Nitrate + nitrite (μ g L)	SD	Reactive silicon (μ g L)	SD	Chlorophyll *a* (μ g L)	SD
2007	1	1	2.3	0.6	1.0	0.7	0.4	0.1	127.8	27.8	5.1	1.5	171.0	23.2	na	na	0.64	0.4
	1	50	2.2	0.8	0.8	0.6	0.4	0.2	108.8	19.1	7.9	1.8	192.8	12.8	na	na	0.32	0.0
	2	1	2.1	0.9	0.8	0.4	0.6	0.3	ND	ND	5.8	3.4	165.6	25.6	na	na	0.58	0.4
	2	50	2.3	0.8	0.5	0.3	0.6	0.3	ND	ND	7.4	1.2	192.0	11.3	na	na	0.38	0.1
2008	1	1	2.1	0.4	0.9	0.3	1.7	1.6	105.8	68.3	4.4	1.0	186.6	20.3	na	na	0.71	0.6
	1	50	2.2	0.3	0.8	0.3	1.3	1.1	ND	ND	8.0	2.0	208.3	8.6	na	na	0.70	0.5
	2	1	2.7	0.4	1.1	0.8	1.0	1.1	76.0	56.2	4.6	1.6	178.4	13.5	na	na	0.64	0.4
	2	50	2.3	0.3	0.9	0.3	1.8	1.3	ND	ND	7.7	4.0	202.0	8.9	na	na	0.58	0.4
2009	1	1	3.0	1.2	0.5	0.5	1.7	0.9	130.0	58.4	4.4	1.3	185.8	16.5	ND	ND	0.54	0.3
	1	50	4.2	3.2	0.7	0.7	1.7	0.6	ND	ND	9.4	2.5	199.3	46.0	ND	ND	0.47	0.6
	2	1	2.5	1.2	1.1	1.1	1.8	0.7	103.0	57.1	4.8	1.6	193.2	14.4	ND	ND	0.34	0.2
	2	50	3.1	1.6	1.0	0.8	2.6	1.0	ND	ND	8.4	2.0	213.7	15.6	ND	ND	0.31	0.2

Appendix A4.–Spiridon Lake weighted mean density and biomass, by species, reported in m^2, 1987–2009.

	Diaptomus [a]			*Cyclops* [a]			*Bosmina* [a]			*Daphnia* [a]			*Holopedium* [a]			TOTALS	
	Density	Biomass	Size	Density	Biomass	Size	Density	Biomass	Size	Density	Biomass	Size	Density	Biomass	Size	Density	Biomass
Year	no/m^2	mg/m^2	mm	no/m^2	mg/m^2	mm	no/m^2	mg/m^2	mm	no/m^2	mg/m^2	mm	no/m^2	mg/m^2	mm	no/m^2	mg/m^2
1987	131,369	503.5	0.96	225,318	425.8	0.74	65,287	203.4	0.57	54,140	133.4	0.75	5,573	93.2	1.17	481,687	1,359
1988	53,344	243.0	1.02	146,961	341.5	0.82	38,694	129.5	0.61	19,044	129.5	1.20	764	3.5	0.73	258,806	847
1989	95,436	292.5	0.89	317,795	386.0	0.60	33,559	101.0	0.56	18,949	83.0	0.96	3,344	23.0	0.82	469,082	886
1990	111,385	460.5	1.00	206,688	415.0	0.76	21,179	69.0	0.59	30,069	175.5	1.10	1,486	7.5	0.69	370,807	1,128
1991	113,778	400.7	0.94	329,343	561.9	0.70	6,786	19.8	0.55	32,956	150.9	0.99	824	18.0	0.76	483,688	1,151
1992	20,328	125.4	1.13	261,093	767.7	0.91	11,825	41.0	0.60	24,893	121.5	1.01	1,780	16.0	0.91	319,919	1,072
1993	11,047	58.9	1.06	269,740	455.4	0.70	16,211	40.4	0.51	23,932	72.3	0.80	3,738	35.2	0.83	324,668	662
1994	8,090	45.4	1.09	240,942	470.5	0.75	27,941	82.1	0.55	39,411	98.1	0.75	7,754	55.0	0.85	324,139	751
1995	12,816	117.3	1.30	213,531	479.3	0.81	29,839	74.2	0.51	28,966	77.5	0.78	19,836	167.0	0.83	304,987	915
1996	3,096	13.8	0.99	384,605	831.7	0.78	28,268	90.7	0.58	20,846	76.8	0.92	8,873	82.9	0.91	445,689	1,096
1997	3,176	26.3	1.26	119,126	287.1	0.82	31,962	89.1	0.54	25,177	105.4	1.00	17,551	131.9	0.84	196,993	640
1998	8,153	45.8	1.09	354,952	481.3	0.63	23,652	60.5	0.52	37,601	131.8	0.90	16,306	52.5	0.58	440,664	772
1999	5,488	27.2	1.06	73,291	155.8	0.78	18,420	60.3	0.58	10,929	37.9	0.92	6,900	28.4	0.63	115,028	310
2000	2,860	16.0	1.14	369,322	466.9	0.61	43,099	103.0	0.51	22,450	60.7	0.79	14,151	86.0	0.76	451,880	733
2001	4,736	46.6	1.34	65,786	171.1	0.85	33,155	94.1	0.55	39,435	124.6	0.84	14,710	158.0	0.97	157,821	594
2002	22,986	125.5	1.12	226,075	365.2	0.69	35,908	104.8	0.55	24,310	118.1	1.02	50,958	348.8	0.80	360,236	1,062
2003	32,677	142.1	1.01	168,425	218.6	0.62	92,258	173.8	0.45	44,984	89.0	0.68	16,720	112.2	0.80	355,063	736
2004	4,977	32.6	1.14	69,849	117.0	0.70	31,871	76.2	0.50	49,921	116.6	0.72	2,070	9.3	0.68	158,687	352
2005	2,239	10.0	0.99	79,485	127.4	0.69	87,265	203.6	0.50	56,098	94.7	0.63	23,073	200.5	0.80	248,159	636
2006	1,002	5.9	1.10	16,876	44.0	0.85	22,707	44.8	0.46	32,925	52.0	0.61	15,146	111.6	0.82	88,655	258
2007	2,763	15.8	1.13	24,982	70.3	0.88	32,657	64.5	0.46	37,354	61.4	0.61	14,262	73.3	0.73	112,017	285
2008	1,181	7.3	1.14	28,047	91.4	0.95	29,617	85.9	0.55	44,013	113.7	0.77	651	8.5	0.96	103,508	307
2009	7,718	59.2	1.24	185,318	420.9	0.81	47,373	135.8	0.55	8,785	21.3	0.73	18,822	162.7	0.90	268,015	800
Mean	28,724	122.7	1.09	190,328	354.4	0.76	35,197	93.4	0.54	31,617	97.6	0.85	11,534	86.3	0.81	297,400	754

[a] Values based on mean density.

Appendix A5.–Temperatures (°C) measured at the 1- and 50-meter bottom strata in the spring (May–June), summer (July–August), and fall (September–October) for Spiridon Lake, 1993–2009.

	Spring		Summer		Fall	
Year	Surface	Bottom	Surface	Bottom	Surface	Bottom
1993	4.7	3.4	12.5	5.0	9.7	6.9
1994	6.0	4.1	14.5	5.0	9.5	5.8
1995	6.5	4.3	13.1	5.2	12.3	8.0
1996	8.5	4.5	13.4	5.0	9.6	5.3
1997	7.1	4.0	15.3	4.6	12.2	4.7
1998	3.7	3.5	12.4	5.2	8.3	6.1
1999	3.4	3.4	10.8	4.8	NA	NA
2000	6.6	4.1	13.1	4.7	9.0	5.5
2001	6.2	3.2	14.4	4.1	11.2	4.3
2002	6.2	3.7	13.7	4.7	10.8	4.9
2003	6.8	4.5	16.8	5.4	10.5	6.0
2004	5.3	3.7	16.5	5.3	9.8	5.8
2005	7.7	4.4	15.4	5.3	10.0	5.9
2006	6.2	3.9	12.1	4.9	10.4	5.6
2007	6.7	3.7	13.8	4.6	10.4	5.0
2008	6.3	3.8	11.5	5.0	10.5	5.1
2009	6.6	3.8	15.1	5.1	10.8	5.7
Avg 1993-2008	6.1	3.9	13.7	4.9	10.3	5.6
2009	6.6	3.8	15.1	5.1	10.8	5.7

APPENDIX B. DAILY SMOLT COUNTS, HYDROACOUSTICS SURVEYS, SURVIVAL DATA, AND APPORTIONED HARVEST

Appendix B1.–Daily sockeye salmon smolt outmigration counts from Spiridon Lake, 1992–2009.

Date	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
23 Apr	0	0	0	0	0	0	16	0	0	0	0	0	0	0	0	0	0	0
24 Apr	0	0	0	0	0	0	106	0	0	0	0	0	0	0	0	0	0	0
25 Apr	0	0	0	0	1	1	302	0	0	0	0	0	0	0	0	0	0	0
26 Apr	0	0	0	1	0	1	201	0	0	0	0	0	0	0	0	0	0	0
27 Apr	0	0	0	0	1	0	140	0	0	0	0	0	0	0	0	0	0	0
28 Apr	0	0	1	0	0	0	693	0	0	0	0	0	0	0	0	0	0	0
29 Apr	0	0	1	9	0	1	3,265	0	0	0	0	0	0	0	0	0	0	0
30 Apr	0	0	7	20	0	79	3,815	0	0	0	0	0	0	0	0	0	0	0
1 May	0	0	9	52	0	44	1,560	0	0	0	0	0	0	0	0	0	0	0
2 May	0	0	16	68	0	457	502	0	11	0	0	0	0	0	0	0	0	0
3 May	0	0	37	337	10	1,202	2,141	0	9	1	0	0	0	0	0	0	0	0
4 May	0	0	11	973	35	2,819	3,799	0	12	0	0	0	0	0	0	0	0	0
5 May	0	0	97	300	181	20,378	7,302	0	15	0	0	0	0	0	0	0	0	0
6 May	353	15,659	49	1,182	2,184	10,123	27,033	0	25	5	0	0	7	20	0	0	0	0
7 May	5,000	4,561	889	1,485	188	5,578	20,765	0	107	2	0	0	11	3	0	0	0	0
8 May	466	13,746	542	3,673	169	16,018	5,057	0	47	6	0	0	5	18	0	0	0	0
9 May	47	6,253	8,740	2,056	228	108,639	12,243	0	182	4	0	6	59	11	0	0	0	0
10 May	6,513	3,953	3,026	4,300	5,196	29,773	78,222	0	90	29	0	5	87	2	0	0	0	0
11 May	8,442	709	426	19,021	3,801	6,011	14,998	0	48	27	0	4	45	0	0	0	0	0
12 May	73,695	31,664	20,666	3,403	7,800	2,638	60,438	0	36	19	18	14	36	13	0	0	0	0
13 May	149,523	50,853	25,627	25,733	3,837	9,926	47,142	2	34	186	7	4	71	15	0	0	0	0
14 May	7,768	91,670	27,718	11,061	14,801	163,534	5,291	296	199	319	10	26	39	44	0	0	0	0
15 May	184,299	89,746	21,212	30,641	3,422	24,775	4,478	6,835	314	2,037	21	214	111	23	0	11	0	57
16 May	101,401	7,280	10,633	51,470	100,606	9,516	43,312	13,396	812	1,243	244	499	410	6	0	1	0	64
17 May	37,735	1,136	19,456	27,961	259,686	56,220	4,046	11,231	1,052	9,385	239	146	196	39	0	22	0	97
18 May	58,892	1,474	67,357	11,441	116,622	41,144	1,713	39,484	6,544	13,919	255	97	0	110	0	7	0	5
19 May	141,103	2,089	33,371	12,812	25,951	45,624	50,534	1,871	20,641	2,685	42	53	192	187	0	13	0	1,059
20 May	96,785	664	13,375	13,322	72,497	58,592	5,968	1,927	8,908	36,752	142	16	1,177	346	87	11	0	362
21 May	62,408	401	58,559	21,205	21,480	67,029	42,070	1,312	32,823	58,067	304	250	3,783	652	103	11	0	1,414
22 May	87,527	6,675	32,340	27,913	4,585	35,836	60,768	366	73,736	17,773	30	322	651	1,409	87	4	0	10,879
23 May	20,501	10,568	31,763	71,338	21,288	78,103	22,817	1,147	19,966	10,407	29	452	6,154	3,446	15	93	0	15,208
24 May	201,062	950	58,745	39,606	63,983	15,154	9,059	228	54,811	194,029	7,906	242	18,208	3,712	54	2,132	0	588
25 May	159,082	3,124	142,295	35,022	7,083	11,291	24,201	1,660	24,604	49,581	12,956	821	20,748	476	39	2,272	0	20,735

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Appendix B1.–Page 2 of 3.

Date	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
26 May	2,257	1,876	40,920	26,843	26,474	19,253	14,968	1,671	43,324	168,398	8,394	0	34,305	1,117	79	5,550	7,042	375
27 May	6,164	98	67,604	7,657	75,210	6,545	6,384	17,217	54,719	252,675	36,165	1,000	15,673	5,453	1	7,991	10,330	2,595
28 May	24,587	71	22,861	26,127	22,810	22,831	32,078	516	48,296	155,436	36,080	639	49,671	20,496	0	45,939	7,945	11,564
29 May	12,150	60	18,634	25,385	7,464	6,206	15,118	394	38,355	124,346	84,090	1,278	160,867	13,026	6,064	31,123	25,120	52,572
30 May	12,350	49	19,779	12,888	21,601	2,323	2,669	31,324	7,098	37,509	38,057	2,954	17,191	4,756	7,933	26,164	2,723	31,695
31 May	16,862	71	15,585	9,552	19,121	1,695	8,621	21,618	13,817	51,019	33,450	5,712	14,221	3,832	4,285	1,478	7,087	21,196
1 Jun	1,380	35	11,830	4,828	18,324	2,891	14,473	19,580	5,820	80,592	46,837	14,808	33,722	32,320	78,233	17,955	44,697	272
2 Jun	444	123	12,038	4,918	14,474	3,206	6,472	365,272	28,697	16,084	20,849	16,287	11,234	44,720	62,093	29,520	170,221	12,584
3 Jun	535	0	4,358	8,476	28,804	1,303	7,579	258,733	20,676	39,065	13,021	10,900	17,718	111,750	89,771	18,788	68,300	43,453
4 Jun	885	0	4,193	15,749	15,744	1,750	2,853	53,796	16,956	90,013	6,263	12,902	23,137	105,905	79,156	82,318	21,862	8,010
5 Jun	494	0	2,582	7,148	17,808	980	3,751	13,901	5,844	33,543	9,887	22,142	11,436	74,213	42,471	16,889	35,475	55,102
6 Jun	793	0	4,223	8,674	8,903	1,430	2,361	5,781	1,069	12,078	25,512	6,844	10,642	106,764	47,826	34,265	60,685	10,044
7 Jun	890	0	875	4,562	7,135	458	3,359	10,811	493	15,817	21,964	12,843	2,818	82,530	27,918	14,673	6,236	2,235
8 Jun	476	0	3,825	9,336	8,221	517	489	11,644	9,783	2,259	9,520	3,538	4,702	35,705	2,926	14,627	6,848	2,089
9 Jun	371	0	1,707	2,885	5,584	379	6,065	3,549	21,043	10,420	12,962	3,346	7,717	32,358	26,342	16,839	13,276	6,954
10 Jun	103	0	2,601	1,862	2,985	361	2,265	56	42,662	3,758	10,132	7,698	12,454	173,879	9,757	21,608	5,918	961
11 Jun	183	0	5,681	1,191	2,449	263	2,366	5,953	7,966	6,332	6,561	10,660	30,226	236,836	3,695	5,399	11,361	143
12 Jun	73	0	1,765	2,561	2,307	336	2,514	16,825	3,059	7,484	5,644	13,739	11,909	74,579	5,159	2,852	6,706	2,231
13 Jun	169	0	2,697	1,368	1,895	500	4,766	7,022	1,254	5,604	5,088	13,858	17,858	65,412	22,359	5,836	4,490	5,041
14 Jun	185	0	2,603	1,527	1,580	191	14,213	3,508	214	5,346	9,081	11,020	5,039	60,112	6,193	5,147	4,207	2,475
15 Jun	868	0	2,269	1,483	553	795	8,065	318	781	3,043	5,278	6,517	8,435	26,508	5,963	7,729	2,384	754
16 Jun	0	0	1,793	2,508	181	0	5,332	421	6,269	3,052	7,346	5,808	4,068	21,123	4,292	3,378	2,173	713
17 Jun	0	0	2,431	1,825	748	0	2,935	375	4,681	2,616	10,569	4,722	3,251	16,320	6,680	2,800	1,066	423
18 Jun	0	0	1,671	2,066	586	0	195	593	22,647	523	9,899	5,762	2,247	9,707	3,885	1,069	1,050	1,211
19 Jun	0	0	988	981	695	0	1,491	160	10,207	6,424	6,960	4,617	1,551	13,356	8,042	5,491	2,558	666
20 Jun	0	0	1,580	853	532	0	181	310	5,410	1,286	1,426	2,695	1,092	8,248	4,328	12,562	1,476	347
21 Jun	0	0	1,011	1,077	253	0	414	828	23,022	807	957	3,624	782	679	2,556	2,631	2,694	450
22 Jun	0	0	2,013	1,319	878	0	2,272	336	5,624	543	3,357	3,852	562	769	1,834	1,237	2,085	150
23 Jun	0	0	1,076	989	1,689	0	216	582	5,344	444	1,461	2,303	1,433	410	1,390	161	1,051	36
24 Jun	0	0	1,338	374	592	0	172	33	10,447	649	5,952	574	739	4,636	890	6,063	329	218
25 Jun	0	0	1,764	748	334	0	73	40	10,385	338	3,530	2,975	266	2,630	471	3,931	68	68
26 Jun	0	0	2,010	478	771	0	1,239	24	15,874	632	828	1,168	644	1,271	373	3,157	63	445
27 Jun	0	0	1,218	350	1,379	0	370	530	3,096	319	1,728	1,813	1,011	2,048	651	4,822	183	108
28 Jun	0	0	979	0	746	0	2,048	373	2,730	418	281	3,314	583	1,838	0	1,853	139	13
29 Jun	0	0	1,757	0	430	0	1,344	462	3,034	750	127	3,328	2,173	0	374	1,003	228	0

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Appendix B1.–Page 3 of 3.

Date	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
30 Jun	0	0	764	0	291	0	806	565	5,495	7	466	2,154	1,508	0	20	528	428	0
1 Jul	0	0	435	0	0	0	483	0	1,818	99	0	1,627	654	927	40	1,193	0	0
2 Jul	0	0	782	0	0	0	385	394	1,814	17	0	1,525	0	1,247	61	978	0	132
3 Jul	0	0	442	0	0	0	287	52	1,336	0	0	1,334	0	438	463	1,355	0	0
4 Jul	0	0	698	0	0	0	160	92	2,340	0	0	685	0	670	0	422	0	130
5 Jul	0	0	0	0	0	0	125	70	365	0	0	1,198	1,925	0	0	126	0	0
6 Jul	0	0	0	0	0	0	174	39	2,120	0	0	3,925	0	254	0	2,836	0	0
7 Jul	0	0	0	0	0	0	211	90	1,232	0	0	1,947	0	0	0	0	0	0
8 Jul	0	0	0	0	0	0	103	24	0	0	0	792	198	0	0	0	0	0
9 Jul	0	0	0	0	0	0	109	29	1,252	0	0	1,279	0	0	0	300	0	0
10 Jul	0	0	0	0	0	0	77	0	0	0	0	1,381	0	0	0	312	0	0
11 Jul	0	0	0	0	0	0	141	273	3,985	0	0	568	0	0	0	0	0	0
12 Jul	0	0	0	0	0	0	181	0	0	0	0	627	0	0	0	0	0	0
13 Jul	0	0	0	0	0	0	0	64	4,000	0	0	0	0	0	0	2,436	0	0
14 Jul	0	0	0	0	0	0	0	0	804	0	0	3,056	3	0	0	0	0	0
15 Jul	0	0	0	0	0	0	0	52	0	0	0	1,239	0	0	0	0	0	0
16 Jul	0	0	0	0	0	0	0	0	0	0	0	2,720	0	0	0	1,500	0	0
17 Jul	0	0	0	0	0	0	0	0	1,000	0	0	1,374	0	0	0	0	0	0
18 Jul	0	0	0	0	0	0	0	0	0	0	0	1,012	0	0	0	0	0	0
19 Jul	0	0	0	0	0	0	0	0	1,000	0	0	4	0	0	0	0	0	0
20 Jul	0	0	0	0	0	0	0	63	0	0	0	0	0	0	0	0	0	0
21 Jul	0	0	0	0	0	0	0	0	718	0	0	1,026	0	0	0	0	0	0
22 Jul	0	0	0	0	0	0	0	0	0	0	0	172	0	0	0	0	0	0
23 Jul	0	0	0	0	0	0	0	0	3,409	0	0	192	0	0	0	0	0	0
24 Jul	0	0	0	0	0	0	0	0	0	0	0	331	0	0	0	0	0	0
25 Jul	0	0	0	0	0	0	0	0	6,000	0	0	110	0	0	0	0	0	0
26 Jul	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27 Jul	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28 Jul	0	0	0	0	0	0	0	0	1,500	0	0	1,432	0	0	0	0	0	0
29 Jul	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30 Jul	0	0	0	0	0	0	0	0	0	0	0	297	0	0	0	0	0	0
31 Jul	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1 Aug	0	0	0	0	0	0	0	0	3,000	0	0	0	0	0	0	0	0	0
2 Aug	0	0	0	0	0	0	0	0	0	0	0	1,033	0	0	0	0	0	0
3 Aug	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4 Aug	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5 Aug	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6 Aug	0	0	0	0	0	0	0	0	0	0	0	1,400	0	0	0	0	0	0
Totals	1,484,821	345,558	850,348	614,993	1,055,186	894,719	746,950	936,118	788,909	1,536,221	521,925	262,851	577,655	1,409,374	564,959	479,411	538,504	327,923

Appendix B2.–Juvenile sockeye salmon estimates based on hydroacoustics fish population surveys in Spiridon Lake, 1992, and 1994–2001.

		Total Fish Estimates [a]		
			95% Confidence Interval	
Year	Date	Number	Low	High
1992	13-Sep	470,587	263,248	677,926
1994	25-Apr	701,521	586,692	816,350
	24-Jun	132,793	85,712	179,874
	26-Sep	562,029	406,414	717,644
1995	2-May	770,610	624,763	916,457
	27-Jun	166,412	136,694	196,130
	29-Sep	1,463,235	970,958	1,955,512
1996	4-May	775,092	480,683	1,069,501
	1-Jul	119,466	98,065	140,867
	19-Sep	658,871	40,670	1,277,072
1997	28-Apr	719,530	520,732	918,328
	7-Jul	592,241	360,022	824,460
	11-Sep	1,577,625	1,203,260	1,951,990
1998	25-Apr	1,341,645	1,226,528	1,456,762
	15-Sep	2,041,377	1,664,655	2,418,099
1999	6-Oct	2,064,419	1,687,922	2,440,916
2000	13-May	1,681,691	1,449,089	1,914,293
2001	1-May	1,754,217	1,469,665	2,038,769
	23-Aug	2,331,383	1,843,645	2,819,122

[a] Total fish population estimates include all species residing in the lake. Townet sampling to determine species composition in the lake was attempted in 1992 and 1994, however, no rearing juvenile sockeye salmon were captured.

Appendix B3.–Sockeye salmon stocking and smolt survival estimates by age and stocking year, 1992–2009.

Juvenile Stocking			Smolt by Age							Percent	Percent	Stocking to
			Age 1.	Percent	Age 2.	Percent	Age 3.	Percent	Total Smolt	Age 1	Age 2	Smolt Survival
Year	Stock	Number	Number	Outmigrant	Number	Outmigrant	Number	Outmigrant	Produced	Produced	Produced	(%)
1991	US	3,480,000	1,466,995	42.2%	85,443	2.5%	6,271	0.2%	1,558,709	94.1%	5.5%	44.8%
1992	US	2,200,000	260,115	11.8%	244,360	11.1%	831	0.0%	505,306	51.5%	48.4%	23.0%
1993	US	4,246,000	599,717	14.1%	299,556	7.1%	1,232	0.0%	900,505	66.6%	33.3%	21.2%
1994	US	5,676,000	314,604	5.5%	135,414	2.4%	2,934	0.1%	452,952	69.5%	29.9%	8.0%
1995	S	4,599,000	918,540	20.0%	237,492	5.2%	301	0.0%	1,156,333	79.4%	20.5%	25.1%
1996	US	4,844,000	654,293	13.5%	216,923	4.5%	373	0.0%	871,589	75.1%	24.9%	18.0%
1997	US	6,700,000	529,726	7.9%	123,458	1.8%	5,133	0.1%	658,317	80.5%	18.8%	9.8%
1998	S	3,340,000	812,267	24.3%	493,529	14.8%	0	0.0%	1,305,796	62.2%	37.8%	39.1%
1999	S	3,564,000	792,029	22.2%	442,975	12.4%	0	0.0%	1,235,004	64.1%	35.9%	34.7%
2000	S	4,397,100	1,093,246	24.9%	92,484	2.1%	914	0.0%	1,186,644	92.1%	7.8%	27.0%
2001	S	1,700,600	441,964	26.0%	34,854	2.0%	1,274	0.1%	478,092	92.4%	7.3%	28.1%
2002	S	952,900	228,857	24.0%	36,882	3.9%	4,264	0.4%	270,003	84.8%	13.7%	28.3%
2003	S	1,417,519	540,748	38.1%	48,326	3.4%	0	0.0%	589,074	91.8%	8.2%	41.6%
2004	S	2,797,644	1,368,763	48.9%	94,932	3.4%	0	0.0%	1,463,695	93.5%	6.5%	52.3%
2005	S	1,201,668	471,241	39.2%	96,795	8.1%	0	0.0%	568,036	83.0%	17.0%	47.3%
2006	S	3,196,512	387,179	12.1%	426,010	13.3%	0	0.0%	813,189	47.6%	52.4%	25.4%
2007	S	1,810,111	117,370	6.5%	203,901	11.3%	–	–	–			–
2008	S	1,049,809	132,681	12.6%	–	–	–	–	–			–
2009	S	1,475,160	–	–	–	–	–	–	–			–
Mean (1991-2006)			680,018	23.4%	194,340	6.1%	1,470	0.1%	875,828	76.8%	23.0%	29.6%

Note: US = Upper Station Lake brood stock.
S = Saltery Lake brood stock.
– = Awaiting smolt emigration.

Appendix B4.–Apportioned (includes harvest outside SBSHA) commercial sockeye salmon harvest from Spiridon Lake enhancement by year, 1994–2009.

Year	Sockeye
1994	267,464
1995	96,621
1996	387,062
1997	147,245
1998	215,514
1999	468,220
2000	202,472
2001	147,295
2002	491,629
2003	633,449
2004	185,961
2005	144,857
2006	88,945
2007	171,341
2008	244,414
2009	155,025
Mean 1994-2008	259,499